GEOLOGICAL SURVEY OF NEW JERSEY.

ANNUAL REPORT

OF THE

STATE GEOLOGIST,

FOR THE YEAR

1876.

TRENTON, N. J.:
JOHN L. MURPHY, STATE GAZETTE PRINTING HOUSE.
1876.

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GEORGE H. COOK, - - - - - - - - New Brunswick.

To His Excellency, Joseph D. Bedle, Governor of the State of New Jersey, and President of the Board of Managers of the State Geological Survey:

SIR—I have the honor herewith to submit my annual report on the operations of the Geological Survey for the year 1876.

With high respect, your obedient servant,

GEO. H. COOK,
State Geologist.

REPORT.

INTRODUCTION.

The Geological Survey of New Jersey has, from its first organization, had for its work a much wider field than belongs to the science of Geology. It has taken notice of our natural and indigenous products, mineral and vegetable, and, besides describing them, has pointed out their uses and economical applications. In this way, it has been an important agent in helping forward that extraordinary development of our population and wealth which has been going on for the past few years. Its work is still in the same direction, and while new objects of study and new uses for our products come up every year, it endeavors to select from them those which are of most pressing importance at the present time. The work of the Survey during the year 1876 has been as follows:'

1. Exhibit of the Geological Survey of New Jersey at the Centennial.
2. Exhibit of New Jersey woods, soils and natural fertilizers in the New Jersey agricultural exhibit.
3. Arrangement of the Centennial collections for permanent exhibition in the Geological Rooms at the State House, Trenton.
4. Making surveys for topographical maps of upper and lower Passaic water-sheds.
5. Analyses, and examinations of water from all parts of the State.
6. Examinations and studies for the geology and chemistry of the fire and potters' clays.
7. Miscellaneóus work in furnishing information in answer to inquiries regarding various natural products.

ASSISTANTS.

Prof. J. C. Smock, Assistant Geologist, has been engaged chiefly with the Centennial exhibits and catalogues, and with the geology and topography of the clay region.

Mr. E. H. Bogardus, Chemist, has been constantly occupied in analyzing waters, minerals, fertilizers and ores.

George W. Howell, Engineer, has been engaged for two months in surveying, leveling and describing ponds, streams and lines of elevation.

Wm. F. Gregory, Surveyor, was engaged for about six weeks in a topographical survey of the Rockaway and Pequannock valleys.

Wm. E. King, Engineer, was engaged for six weeks in levelling for the surveys on the Pequannock and Rockaway.

Wm. R. Whitehead and George McC. Taylor, students of engineering, surveyed and mapped Bear Swamp, near Trenton.

Messrs. E. A. Reiley and R. A. Meeker, students, have rendered valuable service in preparing and arranging specimens for the Centennial.

Fred. A. Canfield, M. E., has given special attention to the exhibition at the Centennial of our rarest and most beautiful minerals.

EXPENSES.

The expenses of the year have been kept considerably within the appropriation.

EXHIBIT OF THE GEOLOGICAL SURVEY AT THE CENTENNIAL.

The exhibit at the Centennial was made on the "allotted floor space, four spaces each, 14 feet by 8 feet, with passage on all sides, in the Main Exhibition Building, located," just north of Column T 70, near the southeast corner of the building. The specimens were arranged in eight cases, two on each space, standing with their backs together, and with high tablets between for the exhibition of the maps of the survey. The effort was made to show full and correct specimens of the results of the survey in all its departments.

A catalogue of the exhibit was prepared and printed, which gave name and short description of four hundred and twenty-six speci-

mens from the various geological formations of the State; sixty-eight specimens of choice and beautiful minerals; thirty-six specimens of building stone, roofing slate, flag stone, limes, cements, &c.; two hundred and fifty-seven specimens of iron ore; twenty specimens of zinc ore; six specimens of copper ore; twenty-six specimens of potters' clays and glass sands; ten specimens of baryta, manganese, and other useful natural products; twenty-two specimens of iron and zinc from New Jersey ores; twenty or more specimens of fire-brick, pottery, alum, glass, &c., from State products; a collection of characteristic fossils from all the geological formations; twenty-four maps; a model of the zinc mine and vein at Franklin Furnace, and the publications of the Geological Survey, in an octavo volume. The preparation of this exhibit met the hearty approval of all, and it is to the active efforts and co-operation of the State officials that it owes its completeness. Hon. Lewis Perrine, Quarter-master General, and Samuel C. Brown, Esq., President New Jersey Centennial Commission, in particular, have given a great deal of time and labor to make this exhibition of State products creditable and pleasing. Valuable and unique specimens were loaned to the exhibition by Fred. A. Canfield, M. E., of Dover, N. J., by the New Jersey Zinc Company, by the Passaic Zinc Company, and by Rutgers College. Joseph F. Talson, of Jersey City, took great pains to make his collection of minerals, from Bergen Hill, perfect and handsome.

The following is the Centennial Commissioners' award for the exhibit:

"The United States Centennial Commission has examined the report of the Judges, and accepted the following reasons, and decreed an award in conformity therewith:

'GEOLOGICAL SURVEY OF NEW JERSEY.

'PROF. GEO. H. COOK, STATE GEOLOGIST.

'*Report*—Large, well selected and well arranged collections, showing (1) all the rocks of the various formations known in New Jersey, including the potters' clay and the green sand; (2) the ores of iron and zinc, and the products of their metallurgical treatment; (3) the building stones; (4) a fine collection of the rare crystalline minerals of the State; (5) plans illustrating the mode of occurrence of the magnetic iron ores, a model of the Franklin Furnace zinc

mine, and the geological maps published by the State Survey; the whole giving a very complete and most instructive view of the scientific and economic geology of New Jersey.

'T. STERRY HUNT.

'JUDGES.

'Prof. Frederick Prime, Jr., Secretary.
Alexander L. Holley,
Prof. J. M. Safford,
S. B. Axtell,
John Fritz,
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Richard Akerman, Sweden.
Mr. Achille Jottrand, Belgium.
Mr. L. Nicholsky, Russia.
Mr. Nicholas Jossa, Russia.
Prof. Dr. Th. Kjerulf, Norway.' "

The exhibit was examined by thousands of visitors from all parts of the world; and we believe this public exhibition of our natural products and resources is, and will continue to be, both creditable and profitable.

At the close of the Centennial Exhibition, the specimens and cases were returned to Trenton, and are now arranged for permanent exhibition in the museum of the Geological Survey. The catalogue is to be printed in the report of the Centennial Commissioners to the Legislature of New Jersey.

AGRICULTURAL EXHIBIT.

The Geological Survey furnished specimens of soils, sub-soils, marls, and other natural fertilizers, and a collection of all the woods growing in New Jersey, for this collection, which was exhibited in Agricultural Hall, at E 17 and 18. It contained samples of one hundred and fourteen soils and sub-soils, representing the kinds found on the several geological formations, and from all parts of the State. Seventy-nine greensand marls, four calcareous marls, and seventeen fertilizers, as shells, lime, muck, &c.

These specimens were exhibited in glass bottles, enough of each being put in to show its characteristic appearance. They represent very fully the greensand marls and miocene marls in nearly all their

more common forms, as found in the clay marls, in the lower, middle and upper marl beds, and in the miocene localities. The soils of the marl region were also well represented by good and fairly average specimens, showing all the varieties of soil found in that part of the State. From northern New Jersey we have a few good soils, typical of large areas of some of our best and most productive land.

These make the nucleus of a collection which will represent all the varieties of soil found within our limits, and they are all good specimens for chemical examinations and study.

Of the woods there were seventy-two species, brought from one hundred different localities, and each specimen was represented in three sections, one being cut crosswise, one lengthwise, and the third aslant. It is a fine collection of native woods.

At the close of the exhibition these specimens were returned to the museum of the Geological Survey at Trenton, for permanent exhibition, and are now arranged there. There are duplicates of many of the specimens, which can be exchanged or given to institutions of science and learning.

TRIGONOMETRICAL SURVEY OF THE STATE.

The work of triangulating the State, and determining the precise latitude of marked geographical points in different parts of the State, has been continued through the year. It is done by the United States Coast Survey, and at the expense of the general government, and at the same time it is done with the object of facilitating and making more complete the work of our Geological Survey.

There are now selected nine primary and three secondary stations, located in New Jersey, mostly on mountain peaks in the middle and northern part of the State, connecting with stations already determined in former coast survey work in the middle and southern part of the State, and extending into New York on the northeast, and into Pennsylvania on the southwest, to connect with similar surveys in progress in those States.

These stations are from ten to thirty miles apart, and the work of the past season has been very trying on account of the unusual prevalence of extreme heat and hazy weather. There have been weeks together in which the signals could not be seen at the distance of ten miles, and it was not uncommon, even when the air was clear,

to find it so unsteady from hot and cold currents that observations could not be made. As each angle has to be measured at least seventy-two times, and the measurements must all agree within 5″ of each other or be rejected, it will readily be understood the work must go on very slowly. Its accuracy is such, however, as to pay for the labor bestowed. An inaccuracy of two inches on the length of a side eighteen miles long could probably be detected.

This work is needed now; we find immediate use for it in the construction of our topographic maps, which are to be used in locating lines for railroads, roads, lines of water supply, and drainage. And this coast survey work, in aid of ours, is looked upon with great satisfaction.

The triangulation map of the State is herewith submitted.

DRAINAGE.

The drainage of the Great Meadows on the Pequest, in Warren county, is still in progress. The outlet is finished, and a great number of stumps, logs, and other obstructions have been taken from the bed of the stream in the meadows. As soon as the outlet was opened, the bed of the stream began to lower as much as the outlet had been cut down, and the deepened channel continued to work its way up stream, and it has really worn backwards for a half mile or more in this way; and the bed of the stream has nearly the same slope that it had before, but several feet lower. The effect of this in draining the meadows is most gratifying; the ground is drying and becoming solid, so that cattle can pasture on it, and rich sweet grasses are taking the place of rushes and wild grass. It promises to be a perfect success. There is some delay just now by the damming of the stream to allow the dredge to float in clearing out a side ditch, but this will soon be removed, and the channel left open for the action of the winter and spring floods.

It is unfortunate that the work is delayed and its cost increased by prolonged and expensive litigation. This, it is hoped, will soon be settled, and the work of carrying out this great improvement be completed and made useful.

The drainage of the wet lands of the Passaic above Little Falls has not yet begun. There is difficulty in getting money in the present state of business in the country, but it is to be hoped some

means will be devised for carrying it out and securing its great advantages.

The Bear Swamp, through which the Pennsylvania railroad passes on the line, about three miles east of Trenton, is an unsightly and discreditable piece of property. If it were drained so as to make it available for pasturage, meadow or cultivation, it would add to our agricultural wealth and remove an ugly blotch from one of the most conspicuous places in the State.

The swamp has been surveyed, and levels taken to find the most convenient place for drains. The map submitted to the Board shows the location of the swamp in its relation to Mount's and Whitehead's mills, and to the Assanpink and Mirey Run. Its area is seven hundred acres. There is nine feet fall in the Assanpink from the foot of Mount's dam to the water surface in Whitehead's mill pond, and the distance is one and five-sixths miles. The swamp along the railroad is also nine feet above Whitehead's pond. A good ditch, four feet wide and three feet deep, for a mile along the railroad through the swamp, and then a ditch, three feet deep and seven feet wide, running northwest from the railroad for a half mile to the Assanpink, would furnish a sufficient outlet for the water and soon dry the swamp. The Assanpink is tolerably clear, though some few obstructions from stumps, logs, brush and sand-bars, might have to be removed. The cost of these main ditches should not exceed two dollars an acre, and probably not half that sum.

WATER SUPPLY.

The subject of a supply of pure water for our large towns and cities has been alluded to in former reports. This year it has been further examined, and the results are herewith submitted. They are somewhat more specific and local than they would otherwise have been, on account of the circumstances under which they were collected. In the early part of the summer, a meeting was held in Newark to consider the question of water supply for the cities and towns in the counties of Hudson, Passaic, Essex, Union, and parts of Bergen and Middlesex. At this meeting the State Geologist, and others from outside the district, had been invited to be present and to take part in the proceedings. A committee was appointed, consisting of the mayors of Newark, Jersey City, Hoboken, Bayonne,

Orange, Bloomfield and Montclair, who were instructed to collect more definite information upon the subject, and for that purpose to ask the Board of Managers of the State Geological Survey for their help. The application was made to Governor Bedle, President of the Board of Managers, and with his approval this work was done. The public importance of it will be appreciated when it is considered that the country interested in this investigation includes all that part of the State between the Hudson river and the First Mountain, and from a line north of Paterson and Hackensack to the Raritan river. With an area of four hundred and eight square miles, it has a population of four hundred and fifty-six thousand, and is increasing rapidly in inhabitants and in wealth, and from its location near the great commercial centre of our country, it must continue to attract a large share of the capital and industry of the State. An abundant supply of pure and wholesome water is indespensable to the proper development of the advantages of this favored district.

The present supply for Newark and Jersey City is drawn from the Passaic river near Belleville. This stream receives the sewage from Paterson, a city of near forty thousand inhabitants. The recent clearing of the channel above Newark, by the United States Government, has given more freedom to the tidal movement of the water, so that salt water from the bay and sewage from Newark may flow further up the stream than they formerly did. On account of these circumstances, there has been much doubt expressed as to whether this water was suitable and safe to be used for household purposes, and hence the inquiry.

In carrying out the investigation, we first submitted the various samples of water to analysis, as follows:

ANALYSES OF WATERS FROM VARIOUS PLACES—IMPURITIES IN 1,000,000 PARTS OF WATER.

	SOLID MATTER.		AMMONIA.		Chlorine.	Sulphuric acid.	Lime.	Magnesia.	SOURCE.	Date of collection.
	Dried at 212° Fah.	Ash after burning.	Free.	Albuminoid.						
1	271.70	208.78	0.133	0.215	91.52	17.658	21.204	13.385	Jersey City Pump Works, high water, . . .	Aug. 31
2	111.54	77.22	0.100	0.190	10.01	8.338	21.204	9.266	" " low " . .	" "
3	223.08	171.60	0.109	0.325	70.07	6.867	20.025	17.503	" hydrant, ...	" 25
4	160.16	125.84	0.100	0.145	61.49	14.300	20.033	15.444	Newark Pump Works, high water, ...	" 31
5	100.10	74.36	0.118	0.195	4.29	7.840	20.033	8.752	" " low "	" "
6	128.70	108.68	0.020	0.180	25.02	6.860	20.020	12.355	" hydrant, ...	" 25
7		71.50	0.080	0.175	5.00	6.864	19.699	12.012	Passaic river at D. & L. R. R. bridge, . . .	" 31
8	77.22	57.20	0.100	0.125	2.80	3.433	16.874	12.355	" " above Two Bridges, ...	July 20
9	72.20	50.05	0.133	0.115	2.90	9.810			" " at Hanover Bridge, ...	Aug. 16
10	145.86	102.96				4.905	20.821	11.880	" " above mouth of Rockaway, .	July 20
11	85.80	78.65	0.093	0.120	2.20	9.809	17.875	12.260	Rockaway river below Dover, ...	Aug. 16
12	64.35		0.021	0.125	1.50	1.962	12.870	9.270	" " at Lower Longwood, . .	" "
13	45.00	35.03	0.080	0.215	1.71	3.924	11.211	7.202	Ramapo " Pompton furnace pond, . .	" 23
14	40.04	28.60	0.059	0.158	2.14	3.924	8.801	6.178	Ringwood " near Pompton, ...	" "
15	60.06	45.76	0.027	0.120	2.14	3.924	11.212	8.237	Pequannock " " "	" "
16	54.34	35.75	0.013	0.175	1.43	3.924	10.010	5.148	Morris Canal, head of Bloomfield Plane, .	" 25
17	134.42	102.96	0.133	0.310	5.72	10.791	28.829	9.266	Hydrant at Elizabeth, ...	" 31
18	174.46	154.44	0.037	0.135	4.29	31.882	48.334	12.360	" " Rahway, ...	" "
19	77.22	57.20	0.027	0.235	6.44				" " Camden, ...	
20	27.50	14.30	0.000	0.158	1.30	3.924	3.703	2.703	" " New Brunswick, ...	
21			0.040	0.195	2.86	2.943	14.300	3.089	Mt. Holly Water Works (1), ...	
22	40.51	35.75	0.026	0.130	2.14	3.923	2.860	4.118	" " " (2), ...	
23	21.45		0.011	0.112	1.40	5.886	5.606	3.089	Hydrant at Hackettstown, ...	Aug. 16

The samples of water were collected in the dryest season of the year, when the flow of the streams is the smallest, and of course when impurities in water are least diluted. The results are given in millionth parts, as upon the whole most convenient. They may be turned into parts in a gallon by dividing them by 17.1. The quantities in any case are very small, the whole of the solid matters in a barrel of the most impure water analysed being less than an ounce.

The *first column* gives the weight of the dry matter left after evaporating one million parts of the water at a boiling heat.

The *second column* shows the weight of the ash or mineral matter left from burning the dry residue of the first column.

The *third column* gives the weight of the free ammonia in the water when it was first collected. This may come from the air or from matters decomposing in the water. A little is found in rain water, but any considerable quantity gives reasonable cause for suspicion of contamination. Corfield says if it amounts to one in a million of water, it must be condemned.

The *fourth column* gives the weight of albuminoid ammonia. This is the animal or vegetable substance in water which, in putrefying, finally forms free ammonia. It is in animal and vegetable substances, and in the filth from them; and in certain stages of their decay or putrefaction, is unwholesome and dangerous.

The *fifth column* gives the amount of chlorine. This is one of the elements of common salt. It is not in the least injurious, but it is not a constituent of pure water. It is always found in the excreta of animals, and its presence in water to much amount is a proof of contamination by sewage. A very little of it is to be found in our mountain streams, much more of it in the streams flowing through a cultivated country, and most in those upon which towns and cities are located.

The *sixth column* shows the amount of sulphuric acid. This is not particularly injurious, but it is of interest to those who use the water for making steam or for manufacturing purposes, and its amount, compared with that of the chlorine, helps to determine the origin of impurities in water, as will appear further on.

The *seventh column* gives the amount of lime. This is one of the chief constituents of hard water. It is not unwholesome in small quantities.

The *eighth column* contains the weight of the magnesia. In the quantities found in these waters, it is probably not unwholesome.

If the lime and magnesia together amount to forty parts or more in a million parts of water, it is called hard water; if less than forty, it is soft water.

The sulphate of lime forms a hard scale in boilers if present in much quantity.

It should be remarked, in regard to water analyses, that there is great difference of opinion as to their value. Formerly, the chief part of the chemical examination was to determine the kind and amount of mineral matter in the water, but longer experience has shown that this is of minor importance, both hard and soft waters being wholesome enough if they are otherwise pure. At the present time, the leading object of the chemist is to determine whether water is free from waste or decaying animal and vegetable substances, and in particular whether it is free from such as contain nitrogen and are capable of undergoing a kind of putrefactive decomposition. Such substances, in the course of their decomposition, yield different products, with more or less active properties, and finally yield ammonia, or nitric acid. Under the head of *albuminoid ammonia* it is intended to include those substances containing nitrogen, but which have not yet been decomposed so as to yield ammonia, or nitric acid. Wanklyn, an English chemist, has devised processes for determining free and albuminoid ammonia, which, in some conditions, are of astonishing nicety, and they have been very generally accepted and adopted by chemists. They have been used in preparing the results in the table of analyses here given. They are satisfactory for the free ammonia, but not for the albuminoid ammonia. In our trials upon water containing known quantities of urea in water, we could not get uniform results, nor detect more than a small part of the urea added. Urea is the important substance sought in the analyses, and it contains the elements which constitute albuminoid ammonia, but it is not accurately found; and there is nothing better at present.

Some points may however be made out from the analyses. From those of Jersey City and Newark waters, compared with those from farther up the Passaic, it is plain that the water supplied to those cities contains three or four times as much mineral matter as that from farther up stream. A comparison of the amounts of chlorine

shows twenty or more times as much in the Jersey City and Newark waters as in those from the upper Passaic; but as the tide flows freely up from Newark Bay to a long distance above the water works pump-houses, it leaves it somewhat uncertain whether the impurity is sewage or salt water from the Bay.

For comparison, some of the constituents in one million parts of sea water and of urine are here given:

TABLE.

	Solid matter burned.	Chlorine.	Sulphuric acid.	Lime.	Magnesia.
Sea water, ...	35300.	19266.	2276.	671.	1475.
Urine, ...		4320.	1241.	224.	212.

The analysis of sea water is taken from Bischof's Chemical Geology. It is the average of analyses of nine specimens of water collected from as many different and remote places in the Atlantic and Pacific oceans. The different samples are remarkably like each other in composition and strength.

The analysis of urine is taken from Watts' Dictionary of Chemistry, and is probably a fair average, though different samples must of course vary widely with the food, mode of living, and health of individuals.

Now, by comparing the ratio of chlorine and sulphuric acid in No. 1 with the same in No. 7, the conclusion can safely be reached that the impurity is part salt water and part sewage, and that the waters 1–6, which are samples taken at high tide, low tide, and mixed in the reservoirs, are decidedly impure.

A comparison of 7 with 8—that is, of the water below Paterson and Dundee—with that above Little Falls, shows only a difference in the amount of chlorine, there being nearly twice as much in the former as in the latter, and it has undoubtedly been contaminated by sewage.

This conclusion can also be satisfactorily reached by testimony.

There is, at the present time, along the Passaic from Paterson to Belleville, and located on a surface of not more than twenty square

miles, a population of very nearly fifty thousand—a population which has more than doubled within the last twenty years, and which has every prospect of continuing to increase for a long time to come. This population is largely engaged in manufactures, and the whole of the waste and filth from the factories, and all the sewage from houses, finds its way into the river. In addition to this the manufacturers' waste, and most of the sewage from Newark and Belleville, with a population of one hundred and twenty-six thousand, are emptied into the river; below the pumps, it is true, but the flood tide carries this polluted water up stream for a long distance, as far up as the pumps certainly, as the analyses show. This pollution of the water is, from the rapid increase of population, growing worse every year.

Water contaminated by filth and sewage, however offensive it may be, is not always, or even generally, poisonous. But it is never safe to be used for domestic purposes. In hot weather the organic matters in it decompose rapidly, producing new and unwholesome substances, which frequently are the causes of sickness and death. Diseases such as typhoid fever, cholera, &c., are conveyed in drinking water to an extraordinary extent, and exposure to air and oxidation destroys them very slowly. Even freezing does not always destroy organic poisons in water.

Every physician can cite cases in which well water, contaminated by soakage from privies and cess-pools, has been the active cause of sickness and death.

A few instances, to show the effects of water polluted by organic and rapidly decomposing substances, are selected from the mass of testimony that has been collected upon this subject.

In the transactions of the New Jersey State Medical Society for 1863, is a report by Dr. Thomas F. Cullen, of Camden, on the "Kensington Diarrhœa." He says:

"Persons only were affected with this disorder who drank of the water supplied by the works formerly owned by the district of Kensington, in the upper portion of the city of Philadelphia.

"The water supplying this reservoir is taken from the Delaware river, near where a creek and culvert empties into it, receiving the filth from numerous privies, sinks, culverts, &c., in a thickly settled and filthy manufacturing portion of the city. Of the residents so supplied with water very many were affected with diarrhœa, and

many fatal cases occurred. The attention of the authorities of Philadelphia being called to this fact, this supply of water was cut off, and a supply from the Schuylkill substituted, during which time there was a subsidence of the disease—no new cases occurring and the majority of those sick recovering.

"On account of an accident to the Schuylkill works the Kensington works again opened, when a return of the disease followed.

"Many of the citizens of Camden are called by their business to that part of Philadelphia, where they remain all day, the mechanical nature of their business making large draughts of water necessary to their comfort. Among this class of our citizens we found many cases of the Kensington diarrhœa, the symptoms of which are diarrhœa, loss of appetite, great thirst, muscular debility; which symptoms, after continuing from a few days to a few weeks, become more severe, with a dry and cracked tongue, cool skin, contracted and leaden-hued, cramps in extremities and abdomen, discharges of a soap-suds character, or perfectly colorless, and very frequent. In fact, in a bad or neglected case all symptoms are present of Asiatic cholera, and the surprise to the practitioner, when called, is that the patients insist, in many instances, on their having been in nearly that condition for the past six, twelve, twenty-four or thirty-six hours, which in fact he cannot at first believe, and does not until he finds them remaining in the same state for twelve or twenty-four hours longer, in spite of vigorous treatment. * * * Some few fatal cases have occurred in Camden.

"It has been denied by some persons that this disease was the result of the water used, but patients of mine who have suffered from it have proved the falsity of the assertion by carrying their daily allowance of water with them for some time, during which time they maintained perfect health, but becoming careless again resorted to the supply there and were again attacked in the same way."

There was a very sudden and severe outbreak of typhoid fever at St. Mary's Hall, Burlington, in the beginning of the winter of 1874. The first case occurred on the 4th of December, and before the 20th of the month there were eighty cases. Sixty remained in the institution, and were all cured. Of the twenty who went away to their friends five died very soon, and two others after lingering for six months. The cause of the disorder was a polluted water supply.

A large well received its supply from the Delaware, and the water was pumped from this for the use of the establishment. Adjoining the well was a large cess-pool, lined with brick and cement, in which the cement had decayed, and allowed a leakage from the cess-pool to the well, by which the water was poisoned. As soon as the cause was known the proper remedies were applied, and the disease was stopped.

The disorder was entirely confined to the young ladies attending the school. Teachers and servants who drank tea and coffee only escaped the sickness altogether.

A similar case occurred at Lake Mahopac, in Putnam county, New York. This beautiful lake in the Highlands, five hundred feet above tide water, at head of Croton river, with abundance of pure water and fresh and invigorating air, is a popular place of summer resort. It is easy of access from New York, and large numbers of citizens go there during the hot weather. A favorite boarding house there was supplied with water from the lake, through an earthen pipe, which conducted it into a large brick cistern, and from that it was pumped to all parts of the building. The increased patronage of the house called for its enlargement. A steam engine was put in to drive the pump, and a new reservoir, connecting with the old one, to supply it with water. Still later, a larger engine and reservoir were constructed, and the old one fell into disuse, but its connections with the drinking-water cistern was not cut off. In the summer of 1871, some cases of typhoid fever, and more of diarrhœa and vomiting, occurred among the guests and occupants of the house. It was found that the disused reservoir received some of the kitchen slops, and that this accidental drainage had rendered it very filthy, and the water from this had flowed back and into the drinking water cistern, contaminating the whole water supply of the house. The reservoir was thoroughly cleansed and the trouble ceased, and being kept clean during the succeeding year the household was entirely exempt from sickness. In 1873 disease appeared again among the guests, but it was found that this originated from neglect to clean the reservoir, and on this being attended to the disorders ceased. In 1874 the proprietorship of the house was changed, and it was opened in the latter part of June with some five hundred guests and attendants. Several of the guests were attacked with disorders of the bowels before the end of the month. Extreme hot weather

came on, the disorders became violent, and typhoid fever set in. Five persons died. The case was again investigated. The connection of the old reservoir, defiled with slops and drainage from the kitchen, was found to be still open to the cistern which supplied the house, and from thence the contamination and sickness came. The whole water arrangement was thoroughly cleansed at once, the old reservoir filled up, and the drainage safely provided for. The cause of sickness being removed, the place is now as healthy as ever.

The fact that cold weather, and even ice, does not always affect the organic impurities in water, or destroy their active properties, is well shown in a report from Dr. A. H. Nichols, of Rye Beach, N. H., published in the Sanitarian for August, 1876. At the beginning of the season of 1875 the guests at one of the hotels there were very generally affected by continued though mild digestive disorders. The attacks were characterized by "giddiness, nausea, vomiting, diarrhœa, and severe abdominal pain, accompanied by fever, loss of appetite, continued indigestion, and mental depression." It was soon found that sickness was confined to a single house. After much fruitless inquiry and investigation it was ascertained that the ice supply for this house was not obtained from the same source with the other houses there. It was cut from a flooded marsh, where the water was about two feet deep, and the water was supplied from a small saw-mill stream, which brought down and deposited in the pond large quantities of saw-dust. This was found to be rotting, offensive in smell, and to be contaminating all the water of the pond. The use of the ice was at once discontinued, and no more sickness occurred. It should be observed that the pond formerly had free opening to the sea, and the water was not stagnant, but had become so by the obstruction of the channel with stones and sand, which were driven in by storms.

An interesting case, illustrating the extreme difficulty of purifying water which has once been contaminated by the germs of disease, is given in the June number of the Journal of the London Chemical Society. It is in a paper by Dr. E. Frankland, "On some points in the analyses of potable waters." He says:

"The researches of Chauveau, Burdon, Sanderson, Klein, and others, scarcely leave room for doubt that the specific poisons of the so-called zymotic diseases consist of organized and living organic matter, and it is now certain that water is the medium through

some, at least, of these diseases are propagated. It is evident, therefore, that an amount of exposure to oxydizing influences, which may resolve the dead organic matters present in water into innocuous mineral compounds, may, and probably will, fail to affect those constituents which are endowed with life. Indeed, instances are not wanting illustrative of the persistency of the typhoid and other similar poisons when they are diffused in water and then exposed to oxydizing influences. One of the most striking of these occurred at the village of Lausen, near Basel, Switzerland. It was investigated with much care and skill by Dr. A. Hägler, of Basel. In this healthy village, which had never within the memory of man been visited by epidemic typhoid, and in which even a single sporadic case had not occurred for many years, there broke out, in August, 1872, an epidemic which simultaneously attacked a large proportion of the inhabitants. About a mile south of Lausen, and separated from it by the mountain or ridge of the Stockhalden, which is probably an old moraine, from the glacial epoch, lies a small parallel valley, the Fürlerthal. In an isolated farm house, situated in this valley, a farmer, who had just returned from a long journey, was attacked by typhoid fever on the 10th of June. During the next two months three other cases occurred in the same house, viz.: a girl, who was attacked on the 10th of July, and the farmer's wife, and their son, who sickened in August. The inhabitants of Lausen were entirely ignorant of what had occurred at this solitary mountain farm, which was cut off from all communication with the rest of the world, when, on the 7th of August, ten of the villagers were suddenly struck down by typhoid fever, whilst during the next nine days the number of cases had already increased to fifty-seven, out of a population of seven hundred and eighty persons, living in ninety houses. In the first four weeks the number of cases reached one hundred (or above twelve per cent. of the population), and altogether, to the close of the epidemic at the end of October, one hundred and thirty, or seventeen per cent. of the population, were attacked, besides fourteen children who were infected at Lausen during their summer holidays, and became ill after their return to schools in other localities.

"The fever cases were pretty equally distributed throughout the entire village, but those houses, six in number, which were supplied from their own private wells, and not from the public fountains,

were entirely exempt. This remarkable difference naturally led to a suspicion that the public water supply was connected with the cause of the epidemic, although the apparently immaculate source of this supply seemed to negative any such suspicion. The water came from a spring situated at the foot of the adjacent Stockhalden ridge. It was there received in a tank lined with brickwork, and carefully protected from pollution, nevertheless a careful investigation into the source of this spring placed beyond all doubt the origin of the infection. Ten years previously it had been proved that direct water communication, through the intervening mountain, existed between the spring and a brook in the Fürlerthal, flowing past the farmhouse in which the typhoid cases occurred. At that time there was spontaneously formed, by the giving way of the soil at a short distance below the farmhouse and close to the brook, a hole about eight feet deep and three feet in diameter, at the bottom of which a moderate stream of clear water was observed to be flowing. As an experiment, the whole of the brook water was now diverted into this hole, at the bottom of which it entirely disappeared, but in an hour or two the spring at Lausen, at that time nearly dry from a long drought, overflowed with an abundance of water, which was turbid at first, but afterwards clear, and this continued until the Fürler brook was again confined to its bed. It was, however, afterwards noticed that whenever the meadows below this hole were irrigated with the water from the Fürler brook, the volume of the Lausen water supply became greatly augmented a few hours afterwards. Now this irrigation, practised every year, was carried on in the summer of the epidemic from the middle to the end of July, the brook being polluted by the dejections of the typhoid patients, for it was in direct communication with the closets and dung heaps of the infected house, whilst all the chamber slops were emptied directly into it, and the dirty linen of the patients washed in it. Soon after the irrigation had begun, the water supplied to Lausen was at first turbid, acquired an unpleasant taste, and increased in volume. About three weeks after the commencement of the irrigation, the sudden explosion of typhoid fever in Lausen occurred.

"In his search after the cause of this outbreak, Dr. Hägler did not rest satisfied with the evidence just recorded, but supplemented it by the following ingenious and conclusive experiments: The hole in the Fürlerthal, already mentioned, was re-opened, and the brook

again led into it; three hours later the fountains of Lausen delivered double their previous supply of water; eighteen cwts. of common salt, previously dissolved in water, were now poured into the hole and soon the water at Lausen exhibited a stronger chlorine reaction, gradually increasing until it became very strong, whilst the proportion of solid matter dissolved in the water augmented three-fold. The passage of the Fürlerthal water to the fountains of the fever-stricken village was thus established beyond doubt, but another interesting question here presented itself: Did the water find its way through the Stockhaldén by a natural open conduit, or was it filtered through the porous material of the old moraine? To decide this point, two and a half tons of flour were first carefully and uniformly diffused in water, and then thrown into the hole, but neither an increase in the solid constituents, nor the slightest turbidity of the Lausen water was observed after this addition. Thus, the investigation of the typhoid epidemic at Lausen, showed:

"1. That the epidemic followed immediately after the use, for dietetic purposes, of water which had received the dejections of persons suffering from typhoid fever, and that it was confined to persons who drank the infected water.

"2. That the water still retains its infective properties after a filtration, which is efficient enough to remove very minute starch granules, but not sufficient at all times to prevent the passage of visible suspended matter in a still more minute state of division.

"3. That spring water which has been polluted with human excrements, before its descent into the earth, and which is subject to visible turbidity, is not always safe for domestic use.

"4. That water which is polluted with *normal*, as distinguished from *infected* excrementitious matters of human origin, may be used for dietetic purposes with impunity.

"Inasmuch, therefore, as no means are known of distinguishing between normal and infected excrements, and as excrementitious matters are liable to become infected constantly with typhoidal, and occasionally with cholera poison, it is not safe to consume water which is contaminated with human dejections. Further, as typhoidal poison is almost certainly organized and living, it is likely to resist oxidation much longer than the dead organic matters with which it is associated; and as this poison is not removed from water by natural filtration through nearly a mile of porous earth, it follows

that the tracing of the previous history of potable water is of prime importance in water analysis."

This testimony is conclusive as to the dangerous character of water that has once been contaminated by poisonous sewage, and it is certain that the Passaic River, from Paterson downwards, is exposed to such contamination. Hence it becomes imperative that a supply of water for domestic uses should be obtained from other and less questionable sources.

A comparison of these waters of the lower Passaic with those above Paterson show a marked difference in favor of the latter. These are all pure enough for household use, and many of them are almost absolutely pure. The streams which form the upper Passaic come largely from a mountainous region which is rocky, rough and still in forest. Of the 750 square miles of drainage area for the upper Passaic, full 550 are in the region of granitic rocks, from which rain water runs off uncontaminated, and as pure as it fell. The remaining 200 square miles are in the region of red sandstone and trap-rocks, and the water dissolves out a little more mineral matter from the soils and rocks, but it is still soft and pure. The population on this area of 750 square miles is between 50,000 and 60,000, and not densely settled anywhere.

To ascertain if the conclusion that the upper Passaic water is pure and fit for all practical uses was a correct one, application was made to John Cooke, Esq., President of the Danforth Locomotive and Machine Company, of Paterson, for information as to the quality of the Passaic water above Paterson, in its household, steam and manufacturing uses. He says:

"In reply to your favor of the 4th inst., I beg leave to say:

"We use the Passaic water for all domestic purposes, and prefer it to any spring water we can get, except in a very dry time in the summer, when there is a slight taste of vegetable matter in it.

"We use it in the boilers at our works, it does not produce scale, seems perfectly free from anything that would produce it.

"It is used by all our dyers and bleachers, who speak in the highest terms of its quality, particularly the silk dyers.

"The Ivanhoe paper mill uses it for everything except the very finest paper, and in a dry time and in winter, when there is less surface water, can use it exclusively.

"You are at liberty to use this information as you deem best, and any further that I can give you will be given with pleasure.

"Yours truly,

"JOHN COOKE."

These particulars, from analysis and from testimony, are sufficient to prove the purity and excellence of the waters of the Passaic, above Paterson.

There are important points suggested by the analyses of the waters used at Elizabeth, Rahway, and Camden, as compared with the purer waters from Hackettstown, Mount Holly and New Brunswick. But the labor of the analyses made has been so great, and the time for making proper inquiries so limited, that conclusions must be deferred with the hope that favorable opportunities and more time may be given to this subject another year.

QUANTITY OF WATER TO BE COLLECTED.

The amount of water which can be collected from any portion of country is dependent on the rain-fall. Water is seen to collect in ponds, lakes, streams, springs and wells, but it all comes from the rain that falls on the districts that slope towards and drain into these natural or artificial receptacles. This drainage may be upon the surface, or it may be through earth, gravel or other open material beneath, but usually not far under the surface. A deficiency of rain-fall is soon seen in the diminished streams and reservoirs; and later the effect is seen in the failure of wells and springs. And the return of seasonable rains soon replenishes the exhausted sources of water supply.

It is to the rain-fall we must then look for data from which to calculate the amount that can be obtained from the *water-shed*, or drainage area of any district of country.

The annual rain-fall is nearly the same in all parts of New Jersey where records have been kept. The showers seem very unequal in different places, but in the aggregate for the year they furnish nearly the same quantity of rain at all the places of observation.

TABLE

Of the annual fall of rain and melted snow, in inches of depth, at various places in and on the borders of New Jersey; also, the greatest and least depths recorded:

PLACES.	Number of years.	Average amount Fall.	GREATEST. Year.	GREATEST. Annual Fall.	LEAST. Year.	LEAST. Annual Fall.
Newark,	33	46.06	1859	57.05	1856	34.07
Lake Hopatcong,	23	42.55	1850	54.61	1866	30.06
New Brunswick,	23	45.41	1873	59.95	1876	30.33
Trenton,	11	46.49	1867	55.60	1870	38.20
Lambertville,	22	44.25	1841	57.36	1856	32.32
New Germantown,	7	44.33	1871	52.45	1872	39.75
Vineland,	11	44.47	1873	54.94	1866	40.73
Greenwich,	6	42.95	1868	47.63	1866	36.95
Philadelphia, Pa.,	50	44.92	1867	61.18	1825	29.57
New York, N. Y.,	36	45.60	1837	65.31	1836	27.57
Flatbush, L. I.,	49	42.47	1859	58.92	1845	32.14

The observations and records for Newark are from 1843–76, and have been kept by Wm. A. Whitehead, Esq.

The Lake Hopatcong records were made by the late W. H. Talcott, C. E., and furnished from the Morris Canal Company's papers by the President, Joseph F. Randolph, Esq. They include the time from 1846–69.

The table of New Brunswick rain-fall was recorded at Rutgers College for 1854–67; by P. Vanderbilt Spader, Esq., for 1868–75, and at the College Farm for 1876.

The Trenton observations were made by E. R. Cook, Esq., and include the years from 1866–76.

The Lambertville observations were made by Lemuel H. Parsons, and have been taken from the American Almanac. They cover the period from 1838–59.

The New Germantown observations were recorded and sent by A. B. Noll, Esq. They cover the period from 1869–75.

The Vineland observations were taken and furnished by Dr. J. Ingram, and include the period from 1866–76.

The Greenwich observations were taken by Miss R. C. Sheppard from 1865–70, and were sent by her for this report.

The Philadelphia rain-fall is from the Pennsylvania Hospital reports, and includes the period from 1825–74.

The New York rain-fall is taken from Dr. Hough's New York Meteorology, second series. It covers the period from 1836–71. The observations from 1836–59 were taken at Fort Columbus, in New York Harbor, and the remainder at the Deaf and Dumb Asylum.

The Flatbush rain-fall is taken from the Brooklyn annual report of the Commissioners of City Works for 1874, and covers the period from 1836–74.

Detailed monthly and yearly registers of the rain-fall at Newark, near the mouth of the Passaic, and Lake Hopatcong, upon its headwaters:

TABLE OF RAIN-FALL AT NEWARK FOR THIRTY-FOUR YEARS,

As observed by WILLIAM A. WHITEHEAD, Esq., and by him prepared for this report.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	TOTAL.
1843....					0.085	1.590	2.285	*22.485	3.610	5.905	3.920	4.145	
1844....	4.985	1.640	4.785	0.390	3.550	2.560	5.820	2.080	2.970	5.515	2.040	3.875	40.210
1845....	3.370	4.210	3.765	1.275	2.155	3.400	2.175	4.800	2.455	2.255	2.875	3.735	36.470
1846....	5.125	4.150	3.415	3.265	8.745	2.175	4.730	4.105	0.550	2.815	8.745	3.745	51.575
1847....	4.655	6.075	4.145	0.850	3.155	6.250	3.305	2.890	11.300	3.460	2.840	5.910	54.835
1848....	1.825	1.815	2.395	1.335	5 985	6.005	2.065	0.955	2.195	4.965	2.720	4.520	36.780
1849....	0.640	2.690	4.855	0.910	4.235	1.090	2.365	8.085	1.600	6.930	2.180	4.470	40.050
1850....	5.010	3.055	4.175	3.030	7.435	3.535	7.420	4.725	4.405	1.725	1.520	5.110	51.145
1851....	2.010	4.500	3.967	6.090	3.930	1.105	6.435	1.520	0.625	3.660	4.610	1.930	40.382
1852....	2.920	2.205	4.805	5.215	2.675	1.720	2.535	4.165	1.740	2.170	5.845	7.545	43.540
1853....	3.090	5.220	3.145	3.015	4.675	3.655	3.250	11,225	5.030	5.080	3,670	1.285	52.340
1854....	1.790	5.020	0.980	11.365	4.170	2.100	3.580	1.125	3.960	2.440	4.310	2.635	43 475
1855....	4.030	3.466	1.895	2.470	2.365	4.525	4.470	4.160	2.250	5.260	2.890	6.500	44.261
1856....	3.370	1.250	2.000	2.570	4.315	3.120	1.410	5.700	2.665	1.400	2.790	3.485	34.075
1857....	3.830	1.580	1.990	7.155	6.030	5.345	5.080	4.015	3.810	3.955	0.870	5.785	49.365
1858....	3.405	2.495	1.010	3.852	4.995	4.650	2.995	4.210	1.410	3.010	4.785	4.260	41.077
1859....	6.055	3.800	6.885	5.305	2.250	3.945	4.025	6.265	6.985	2.550	3.785	5.200	57.050
1860....	2.320	2.710	1.225	2.510	5.000	1.815	2.720	6.235	5.650	2.835	6.715	3.420	43.155
1861....	4.465	1.885	4.915	4.920	5.190	2.600	1.120	3.970	3.260	2.865	6.425	1.990	43.605
1862....	5.415	3.695	3.995	3.215	3.045	6.605	3.020	3.005	2.125	4.265	4.455	1.850	44.690

TABLE OF RAIN-FALL—Continued.

1863....	4.270	4.250	5.250	5.835	4.490	1.045	5.955	4.975	1.300	3.445	2.610	4.575	48.000
1864....	1.730	0.825	3.145	3.670	5.280	1.855	2.675	3.210	4.680	2.675	3.950	4.760	38.455
1865....	4.090	4.570	4.890	3.340	5.730	3.485	6.735	3.935	3.210	4.685	3.300	4.385	52.355
1866....	1.740	5.070	1.820	2.820	4.400	2.505	1.840	5.345	5.470	3.970	2.090	2.910	39.980
1867....	1.610	5.640	4.395	2.575	6.550	9.745	3.755	10.615	1.235 *	4.620	1.945	2.045	54.730
1868....	3.275	1.620	2.170	5.255	6.925	5.895	8.535	4.755	8.955	1.250	4.375	3.845	56.855
1869....	3.420	5.055	4.670	1.150	4.670	5.845	3.690	1.555	2.540	6.820	3.085	5.435	47.935
1870....	4.725	4.265	4.555	7.000	1.995	3.125	6.965	3.095	2.795	4.750	2.460	2.185	47.915
1871....	3.035	3.045	4.990	3.685	3.950	7.105	4.140	5.310	1.990	6.026	3.990	2.175	49.441
1872....	1.845	1.775	3.880	3.745	3.075	4.270	8.940	6.625	3.240	3.110	4.175	3.785	48.465
1873....	5.820	3.885	2.760	5.835	3.755	1.715	6.615	7.765	3.550	3.740	4.670	2.470	52.580
1874....	5.670	3.168	2.135	8.715	2.755	3.580	4.230	2.785	9.050	2.435	2.860	2.810	50.193
1875....	3.310	2.400	3.820	3.135	1.595	2.325	5.985	10.215	1.930	2.870	4.360	2.610	44.565
1876....	1.200	5.355	10.000	3.305	3.045	1.585	3.060	2.450	7.505	1.260	4.040	2.515	40.320
Means....	33 years. 3.456	33 years. 3.403	33 years. 3.721	33 years. 3.903	34 years. 4.182	34 years. 3.585	34 years. 4.233	34 years. 5.846	34 years. 3.707	34 years. 3.668	34 years. 3.723	34 years. 3.672	34 years. 46.057
Greatest..	6.055	6.075	10.000	11.365	8.745	9.745	8.940	22.485	11.300	6.930	8.745	7.545	57.050
Least.....	0.640	0.825	0.980	0.390	0.085	1.090	1.120	0.955	0.550	1.250	0.870	1.285	34.075

* Very remarkable—perhaps unprecedented.

SEASONS.

	Spring Months.	Summer Months.	Autumn Months.	Winter Months.
Greatest quantity in any one year, - - - -	1854, 16.515	1843, 26.360	1847, 17.600	1852–3, 15.855
Least quantity in any one year, - - - - -	1855, 6.710	1854, 6.805	1856, 6.865	1871–2, 5.795
Mean quantity, - - - - - - - - - - - - -	11.806	13.664	11.098	

Table of inches of rain and melted snow observed at the outlet of Lake Hopatcong,* for each month from January, 1846, to December, 1869.

Taken from the rain-gauge and feed record books in the Morris Canal office, Jersey City, N. J., kept by Wm. H. Talcott, Engineer and Superintendent.

Furnished for this report by Joseph F. Randolph, Esq., President Morris Canal Company, and copied by L. B. Ward, C. E.

TABLE.

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	TOTAL.
1846	3.88	0.42	6.34	2.03	4.88	3.64	7.17	7.78	0.87	3.23	5.76	4.12	50.12
1847	4.26	5.84	4.18	0.25	2.76	3.94	5.35	2.59	10.84	3.50	1 61	7.30	52.42
1848	2.02	1.44	2.49	1.95	5.90	4.04	3.14	0.50	2 02	3.89	4.88	6.09	38.36
1849	0.48	1.34	3.90	2.40	5.25	1.33	1.37	5.66	0.50	9.47	2.77	4.75	39.22
1850	3.67	4.66	3.56	3.37	6.56	1.81	7.91	5.75	7 58	2.68	1.96	5.10	54.61
1851	0 82	4.71	2.27	6.59	4.37	1.36	3.85	1.38	1.49	4.41	3.31	3.00	37.56
1852	2.91	3.05	3.48	5.25	2.36	2.17	5.17	6.15	2.05	2.82	6.12	5.54	47 07
1853	1.75	4.01	2.86	3.84	6.01	4.06	5.72	5.21	2.85	6.13	4.42	1.68	48.54
1854	2.71	4.07	1.07	7.35	5.36	3.85	5.17	1.55	5.80	2.13	3.95	2.10	45.11
1855	3.43	0.40	1.55	2.67	6.04	7.64	7.51	2.02	1.86	9.94	3.03	7.24	53.33
1856	1.45	0.52	0.82	2.74	4.14	4.02	0.90	8.55	6.03	1.42	1.97	5.10	37.66
1857	1 50	2.20	1.62	6.66	6.22	4.63	4.75	4.69	2.67	4.56	2.24	5.66	47.40
1858	2.43	1.84	0.40	3.21	6.37	4.15	4.24	4.21	1.96	2.72	4.05	3.83	39.41
1859	5.15	2.87	7.54	5.03	2.10	3 99	3.25	6.62	8.73	1.87	4.09	2.09	53.33
1860	2.12	2.78	0.91	2.17	4.56	2.07	2.79	6.37	2.79	2.04	6.37	1.90	36.87
1861	2.32	1.33	3.66	6.10	3.03	1.72	2.01	3.68	5.05	1.65	4.64	0.75	35.94
1862	3.37	1.50	2.48	2.69	1.89	6.10	2.84	1.97	2.08	3.65	2.97	0.75	32.19
1863	2.62	2.90	3.64	2.90	2.52	0.93	3.91	3.07	2.11	3.90	2.66	3.55	34.71
1864	0.98	0.46	2.25	3.31	7.69	1.32	1.66	5.01	3 17	1.36	2.68	1.61	31.50
1865	2.42	1.99	4.23	3.51	5.17	3 62	5.26	2.03	1.63	3.16	2.24	3.11	38.37
1866	0.61	4.54	0.60	2.13	2.49	3.63	1.92	3.05	4.44	2.21	2.41	2.03	30.06
1867	0.63	1.92	1.88	3.11	6.91	7.29	3.53	10.70	0.35	2.98	1.68	0.60	41.58
1868	1.97	0.97	0.80	2.46	5.33	7.24	3.39	3.37	11.44	1.04	3.90	1.02	42.93
1869	3.43	2.78	4.41	1.51	4.29	3.37	2.10	1.58	7.12	9.82	8.46	4.03	52.90
	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.	
Average	2.372	2.439	2.790	3.468	4.675	3.659	3.954	4.312	3.976	3.774	3.674	3.456	42.55
Greatest	5.15	5.84	7.54	7.35	7.69	7.64	7.91	10.70	11.44	9.94	8.46	7.30	54 61
Least	0.48	0.40	0.40	0.25	1 89	0.93	0.90	0.50	0.35	1.04	1.61	0.60	30.06

SEASONS.

	Spring.	Summer.	Autumn.	Winter.
Average	10.932	11 926	11.424	8.260
Greatest	1859, 14.670	1846, 18.590	1869, 25.400	1847, 14.220
Least	1866, 5.220	1851, 6.590	1867, 5.010	1848, 3.540

* Lake Hopatcong has an elevation of 914 feet above the sea level, and is 50 miles inland.

From these registers, and their slight differences from each other, we may safely infer that the annual rain-fall over all parts of New Jersey is nearly the same, and it may be set down in figures at thirty inches. The lowest observed annual rain-fall is 27.5 inches.

The rain that falls upon the ground does not all run off in the streams. A considerable portion is evaporated from the surface of the earth and water, and some is taken up by vegetation. In hilly countries, and where there is much rock, more water runs off at once in the streams than in countries which are less hilly and with more gravel and earth on the surface; though in the latter case the streams are much more uniform in their flow.

In calculating for water supply, we can only depend upon the amount which falls in the driest years. On the Croton water-shed, it has been found that 60 per cent. of the rain-fall runs off in the streams. In most cases, however, only about 40 per cent. of the rain-fall escapes in the streams. For the purpose of our calculations, we shall assume that 12 inches of the annual rain-fall can be collected in streams and reservoirs, this being 40 per cent. of 30 inches, our minimum rain-fall, nearly.

That estimates based on the annual collection of a cubic foot of water from each square foot of surface are not too large, is proved by the experience of the Morris Canal Company with their reservoirs Lake Hopatcong and Greenwood Lake.

Lake Hopatcong, originally, covered 1,500 acres, and by raising it 10 feet it covered 2,800 acres. This gives an average of 2,150 acres, which is 3½ square miles. The whole drainage area for the lake is 27 square miles, which is 7 7-10 times the area of the lake. A rain-fall of 1 foot on the whole water-shed would only raise the lake 7 7-10 feet. But it is generally drawn down more than this below high water mark for the uses of the canal during the season of navigation, and yet the lake has sometimes been filled between December 1st and February 1st; generally, it is filled by the 1st of March, though in some cases it has not been filled till the middle of May. These times cover only half the year or less, and the inference is conclusive that more than a foot of rain-fall can be stored from this water-shed. The Stanhope mill has rights to the original water-power on the outlet, and an opening of 10x36 inches is kept for this use. A large draught is made upon the water of the lake for the mill, even during the time when it fills so rapidly. It

is a common observation, that the lake rises about twice as much as the rain-fall in the two days following a rain.

Greenwood Lake has been raised, by a dam, 13 feet. Its drainage area is 32 square miles, and its surface is 4 square miles. It has never been largely drawn upon for the uses of the canal, seldom being lowered more than 2 feet; but it furnishes water-power to Hewitt Furnace, and there is a gate drawn constantly of 5x36 inches.

This draws out a large quantity. The lake is now down 7 feet, but is expected to be full before spring. The water has been known to rise 3 feet by a single storm; one of the rains this fall raised it 6 inches. It is sometimes raised so as to be 2 or 3 feet higher than the dam.

From an acre which is 43,560 square feet of surface, then 43,560 cubic feet or 326,700 gallons of water can be collected in a year. And from a square mile there can be collected 27,878,400 cubic feet or 209,088,000 gallons in a year, which is equivalent to a daily supply of nearly 900 gallons per acre or 572,844 gallons per square mile.

The water-shed of the Passaic and its branches, above Little Falls, is 750 square miles.

This drainage area of the Passaic is made up from that of its branches, which, for purposes of calculation, it may be well to set down separately.

The Ramapo* rises in Orange and Rockland counties, New York, and runs through Bergen county, N. J., with a drainage area of 108 square miles in the former State and 40 square miles in the latter, equal to..............	148 sq. m.
The Ringwood* rises in Orange county, N. Y., and runs through Passaic county, N. J. It has a drainage area of 32 square miles in New York and 76 in New Jersey, equal to..	108 sq. m.
The Pequannock* rises in Morris, Passaic and Sussex counties, in N. J., and is the boundary between the two first named. It has a drainage area of 28 square miles above Oak Hill, and in all of........................	82 sq. m.

*The Ramapo, Ringwood and Pequannock Rivers unite at Pompton, and form Pompton River, which runs into the Passaic at Two Bridges.

The Rockaway River has its whole course in Morris county. Its drainage area above Baker's Forge is 30 square miles, the whole above Denville is 100 square miles, and its entire area above its mouth, near Pine Brook, where it joins the Passaic, is......................	165 sq. m.
The Whippany River, which rises near Morristown and runs into the Rockaway near its mouth, has a drainage area of..	59 sq. m.
The Passaic, which rises near Mendham, in Morris county, and retains its name throughout its course to Newark Bay, has a drainage area of 51 square miles above Millington, of 35 square miles in the valley southeast of Long Hill and above Page's dam at Chatham, and of 102 square miles between Chatham and Little Falls, including the area up to Pompton, being in all.	188 sq. m.
Total area of the Passaic water-shed..................	750 sq. m.

This area is capable of yielding a daily supply of 429,633,000 gallons of water if a depth of 12 inches of rain-fall can be collected, and the experience at Lake Hopatcong and Greenwood Lake proves that it can be done.

The Passaic water is used at the Falls in Paterson and at Dundee for driving machinery, for the water supply of Paterson and in part for the supply of the Morris canal. The quantity daily used for these purposes may be estimated in this way. On the upper raceway in Paterson there are 34 square feet of water leased. A square foot is the descriptive term for the water that can flow through a rectangular cast iron gate-way 6 inches high and 24 inches long, with its lower edge on a level with the monument in the bottom of the raceway. This water falls 22 feet, and is said to equal 17 horse power for each square foot. With the wheels now in use, it probably exerts a force of 16 horse power in driving machinery and loses 5 horse power in the friction and resistance of the water-wheel, or 21 horse power in all. A horse power is 33,000 pounds falling 1 foot in a minute, or 1,500 pounds falling 22 feet in the same time. To continue that power for 12 hours would require 720 times as much water, which is 1,080,000 pounds or 135,000 gallons; and the 714

horse power of the 34 square feet would use 96,390,000 gallons of water daily. The Dundee works only use over the same water which has already done duty in Paterson. The Paterson water works may consume for their water-wheels and their water supply 13,000,000 gallons a day, and the whole quantity needed daily may amount to 110,000,000 gallons. In the driest seasons of the year the quantity flowing in the stream is much less than this, probably not as much as 100,000,000 gallons a day. The Morris canal draws its supplies of water from Lake Hopatcong, which is in the water-shed of the Musconnetcong, and so of the Delaware river, and from Greenwood Lake, which is on the head waters of the Wynokie branch of Ringwood river. The latter holds back a part of the water which falls in the water-shed of the Passaic. It has a drainage area of 32 square miles. For this storage for the use of the canal there must be an allowance of 18,332,000 gallons.

The whole Passaic water-shed, then, may be depended on for supplying daily..........		429,633,000	gallons.
Deduct for Paterson water-power....	96,390,000		"
" " " water works...	13,000,000		"
" " Greenwood Lake.........	18,332,000		"
		127,722,000	"
And there remains..................................		301,911,000	"

Which now run to waste in freshets. A large part of this is capable of being collected in storage reservoirs and used for water supply, or for giving an enlarged and steady water-power.

It is not desirable to shorten the valuable, industrial and economic uses of the water as it is now applied. But the natural ponds in the mountains could easily be increased in capacity by damming, or by lowering their outlets, and putting in gates to regulate their discharge; and reservoirs could be made in the narrow and deep mountain valleys, sufficient to hold all the water needed for a long time to come, and in locations where the purity of the water would be beyond question.

The Passaic river, from Two Bridges up to Chatham, runs through a very flat country, and with but little fall. The channel is deep for the whole distance, but in times of heavy rain the river overflows its

banks, and covers with water the flat lands on its borders. In summer, when the meadows are covered with standing grass or other vegetation, the freshets subside very slowly, and great damage is done to health and property. The overflow is caused by the slackness of the current of the river. The obstructions to the flow are:

1. A bar of earth and boulders across the stream just above the mouth of the Pompton, at Two Bridges.

2. A ledge or reef of trap-rock across the stream at the head of Little Falls, which is of about the same height with the bar at Two Bridges.

3. A strong stone dam built just below the reef, which is about a foot and a half higher than either the reef or the bar.

These effectually obstruct the free flow of water in the stream. The lowering of the obstructions seven feet is, from the depth of the channel above, feasible, and comparatively inexpensive; and when done would lower the water surface to almost the same extent. By this change the water could be kept within the banks of the stream after ordinary rains; and in times of heavy rain the overflow of water would soon drain off. The plan for this improvement has been matured, but its execution is delayed on account of the expense to be incurred before work can be begun. It is greatly needed for its sanitary and economical benefits, and it would improve the quality of the water in that portion of the Passaic.

Surveys of valleys have been made on the Rockaway, Pequannock, Ringwood and Ramapo this year, in which deep, capacious and unpolluted reservoirs can be made, which would hold a daily supply of more than 100,000,000 gallons. The rough maps of these surveys are drawn, but there is much more work to be done on them before they would be ready for public inspection.

The supply from natural ponds is least expensive, most quickly obtained, and with less change in the arrangements of property. To get more definite information regarding some of the ponds from which supplies could be drawn, George W. Howell, C. E., was instructed to examine a number of them and report the result, which he has done as follows:

"In accordance with your instructions I have made an examination of various lakes or ponds in Passaic, Morris and Sussex counties, especially with the view of ascertaining the extent of surface which is or may be flowed, the capacity for storage of water, and

also their respective drainage areas, together with such other items of information as may be of service in defining their utility in supplying and storing water, a report whereof is hereto annexed.

For convenience of reference I have arranged the lakes in the order of their outlets, classifying together those respectively that flow (I) into the Ramapo River, (II) the Ringwood River, (III) the Pequannock River, and (IV) the Rockaway River.

I. THE RAMAPO RIVER.

1. *Franklin Lake* lies about three miles directly east of Pompton Furnace. It covers an area of 94 acres and drains about 1,000 acres, the drainage area being about equally divided between mountain slopes and gravelly farming land. There are numerous small ponds in the vicinity, some of them having no visible inlet or outlet, and all of them nearly, if not altogether, of the same level. Crooked Lake, a pond of inconsiderable depth, but some 30 or 40 acres in extent, is said to rise and fall with Franklin Lake, the residents of the vicinity maintaining that there is some subterranean connection between the two. About half a mile west of Crooked Lake is Crystal Spring, which discharges large volumes of water, supposed to be derived from the lakes, which, collectively, are known as "The Ponds." Singack Brook, rising in a ravine a little to the south of Franklin Lake, is supposed to have a similar origin. A few years ago one of the ponds was observed to rise to a much higher elevation than ordinary, and from no known cause, so much so, that it became necessary to change the location of a public road, which had been submerged. After remaining thus for a year or two, the pond subsided to its former level, which it has since retained.

The outlet of Franklin Lake, which is smaller than the inlet, runs for about 500 feet through a level meadow, when, with about 7 feet head, it drives a small water-wheel. The head has been obtained rather by lowering the tail-race than by a dam.

Lowering the surface of the lake 5 feet would diminish its size perhaps one-third.

Raising a dam of 5 feet at the outlet would overflow 75 to 80 acres more, the greater part of the addition being a cedar swamp at the head of the lake. Such a dam would be 300 feet long. A higher dam would be over 1,000 feet long, and it is quite doubtful

whether the first mentioned rise of 5 feet in the surface could be maintained, owing to the porous, gravelly nature of the soil, and the probability that some connection exists between the various ponds in the locality.

2. *Rotten Pond* takes its drainage wholly from the mountains, and lies one and a half miles southeasterly from Wynokie. The original surface was about 80 acres, which has been reduced to 20 acres by lowering the outlet some 6 feet. Should the present surface be raised 10 feet by a dam 4 feet high, fully 100 acres would be covered. The drainage area is about 1,200 acres.

3. *Negro Pond,* a long narrow pond between the mountains, a little east of Shepherd's Pond, lies partly in New Jersey and partly in New York, about one-quarter of a mile east of the 19th milestone. It covers an area of about 100 acres, and drains about 900 acres, wholly mountainous. The ordinary surface can be lowered several feet without uncovering much land, and the dam can also be raised 4 or 5 feet, and would flow 25 to 30 acres more.

II. THE RINGWOOD RIVER.

1. *Mud Pond* lies one and one-half miles north of Bloomingdale, and has its outlet in a small stream, which crosses the Montclair and Greenwood Lake Railway near the first public road, north of Pompton Junction. Its area is 50 acres and drains 1,600 acres, chiefly mountainous. It is surrounded by a cranberry marsh and other low lands, which would be covered to the extent of 70 acres by raising the present surface 10 feet. The outlet has been lowered 4 feet through the rock. A dam 6 feet high would be 800 feet long. The present outlet runs through the marsh for 300 feet and then falls rapidly, and could be lowered without great expense.

2. *Tice's Pond* is a natural lake one mile east of Boardville. Its water surface is 40 acres, but before the outlet was lowered five feet, for a distance of several hundred feet, the area was nearly, or quite, 100 acres. An area of 125 acres would be covered by raising the original surface three to five feet. The dam required would be 400 feet long. The drainage area is about 800 acres; mountainous.

3. *Shepherd's Pond* has had its natural surface drawn down four feet. It covers about 90 acres, and, owing to its steep shores, but little more land would be covered by raising it 10 feet. A dam of

150 feet would be sufficient. The pond lies wholly in New Jersey, near the New York line, about half a mile west of Negro Pond, and drains 1,000 acres, chiefly of mountain forest land, but with a small area of rough clearing. The water is said to be of considerable depth.

The outlets of Shepherd's and Tice's Ponds unite near Boardville and enter the Ringwood River, along which, between Boardville and Wynokie, have been several large furnace and forge ponds, but whose dams have been more or less broken away.

4. *Greenwood Lake*, the head of Wynokie creek which flows into Ringwood River, has an area of a little more than 4 square miles, and has a water-shed of 32 square miles. It is used as storage for the Morris Canal. The surface of the lake is 13 feet above its original level.

III. THE PEQUANNOCK.

1. *Macopin Pond* or *Echo Lake* is situate two miles northeast of Newfoundland. Its area is 363 acres, and by raising the surface five feet an area of 412 acres can be obtained. The depth is 40 to 50 feet. The pond can now be drawn down four feet by means of a flume. The surface also can be raised five feet by a dam 250 feet long. A greater rise than five feet would flow a tract of several hundred acres, called the "Pine Hammock," lying at the head of the lake. The drainage of Macopin Pond is 1,700 acres. An additional drainage of 1,500 acres can easily be procured, at little expense, by turning a stream to the east into the pond. The drainage is divided between mountain forests and rough farm land, about in the proportion of one to two.

2. *Hank's Pond*, two miles north of Newfoundland, covers about 80 acres. It is a natural lake and has been lowered four feet, and can be still more drawn down by cutting a channel 500 feet long. The surface can also be raised above its original height by a dam 300 feet long, thus affording large available storage capacity. By raising the dam 120 acres would be flowed. The drainage area is four square miles, wholly mountainous.

3. *Cedar Pond*, one and one-half miles northeast of Hank's pond, draining entirely from mountain slopes, has had a natural surface of 125 to 140 acres, but has been reduced to about 96 acres by lowering

the outlet. Its vertical capacity is about 7 feet, and drains an area of about 800 acres.

4. *Buck Mountain Pond,* four miles north of Newfoundland, has an area of 75 acres, but can flow 120 acres by means of a dam 250 feet long, and can be used with 10 to 12 feet head. It drains two and one-half square miles of mountain slopes. The outlets of Hank's, Cedar and Buck Mountain Ponds unite and form Cedar Brook, which flows through Clinton, giving opportunities for artificial reservoirs on that stream.

5. *Dunker Pond* lies one and one-half miles north of Stockholm, and has a present surface of 25 acres. The outlet has been lowered through rock at considerable expense, thereby reclaiming a large tract of rich soil, similar in character to the Bog and Fly in Morris county. A dam 100 feet long and 10 feet high would make a lake two to two and one-half miles long and half a mile wide. The drainage area is about five square miles, principally rough and mountain lands.

6. *Canistear Pond* is an artificial pond three miles north of Dunker Pond, and covers, when full, 70 acres. By raising the dam 600 feet long and 5 feet higher 120 acres may be flowed, and 20 feet head may be obtained. Drainage area about 2,000 acres, one-third farming land and the remainder forest and mountain.

7. *Pine Hammock,* at the head of Canistear Brook, flows about 100 acres, and is an artificial pond used as storage for Canistear Pond. Drainage area probably two to three square miles.

8. *Timber Brook Pond,* which lies two miles southwest of Charlotteburg, has an area of 72 acres and can draw down five feet. Raising three feet higher, thus giving eight feet head, would flow 25 to 30 acres more. Raising the surface of the pond would make it necessary to lift several hundred feet of the track of the Green Pond Railroad, it being within two to three feet of the surface of the water. This pond has a drainage area of about 800 acres, one-half forest and one-half rough, poor farm land.

9. *Stickle's Pond,* lying about two miles east of Timber Brook Pond, has its outlet through Stone House Brook into the Pequannock River, at Bloomingdale. Its area is 101 acres and can be drawn 10 feet. A dam 5 feet higher than the present dam, and 800 feet long, would flow but little more land. The drainage is about 1,800 acres, wholly in forest and mountain.

IV. THE ROCKAWAY.

1. *Split Rock Pond*, five miles northwest of Boonton, has an area of 237 acres, and drains six and one-quarter square miles, almost wholly mountainous and forest. Twenty feet available head can be obtained by raising the dam two feet, the length of the dam being 200 feet.

2. *Durham Pond*, near the head of Split Rock Brook, and used as a storage for Split Rock Pond, covers an area of about 65 acres and drains about 1,000 acres, one-half woods and one-half rough farming land. The present dam is 900 to 1,000 feet long, and if raised would flow 30 to 40 acres more. The pond could be drawn down four feet.

3. *Green Pond* or *Green Lake*, a noted resort four miles southwest of Newfoundland, contains 560 acres and drains two and one-half to three square miles. It has great depth, no inlets and a small outlet.

4. *Denmark Pond*, on Burnt Meadow Brook, a tributary of Green Pond outlet, drains two and one-half to three square miles, and has an area of about 175 acres. It receives its waters from forest and rough farm land.

5. *Midde Forge Pond*, on Green Pond Brook, receives the waters of Green Pond and Denmark Pond, and contains about 70 acres.

6. *Dixon's Forge Pond*, on a tributary of the Rockaway River, about two miles south of Split Rock Pond, covers an area of 60 to 75 acres, and has a drainage area of one and one-half to two square miles, mostly rough land.

7. *Shongum Pond*, five miles northwest of Morristown, and at the head of Den Brook, drains two and one-half to three square miles of rough land, and embraces an area of 125 acres. Increasing the height of the dam five feet, thus giving ten feet head, would cover an area of 165 acres.

In addition to the above ponds, which are already in existence, a large number of artificial reservoirs can doubtless be constructed, affording valuable additional storage, and utilizing the rain-fall over a wide extent of mountain lands. A few of these are herewith given:

1. On the outlet of Mud Pond, one-quarter of a mile above the Montclair and Greenwood Lake Railway, a dam 250 feet long can

be erected, which, if 15 feet high, would flow 100 to 125 acres, and would receive the drainage of four to five square miles.

2. Along the Ringwood River, between Boardville and Wynokie, as has hereinbefore been mentioned, are several forge and furnace sites, the dams of which have been broken away, but which, by being rebuilt, would afford very large storage facilities.

3. One mile west of Hewitt Furnace, on a stream flowing easterly, a reservoir of 75 to 80 acres could be made by a dam 150 feet long and 15 feet high, and would drain about two square miles.

4. About three miles due west of Boardville is a tract of land which has been drained, at some expense, but which it is said could be converted into a reservoir of 140 or 150 acres with little difficulty. A large drainage of several square miles finds its outlet through the locality.

5. On the outlet to Stickle's Pond, a dam 15 feet high and 350 feet long, at the old forge site below the pond, would flow 80 to 100 acres, chiefly meadow, and would drain 1½ to 2 square miles, independent of the drainage of Stickle's Pond.

6. At Mount Pleasant, on Green Pond Brook, a reservoir of 800 acres, and capable of drawing 10 to 12 feet, may be constructed by means of a dam, at a moderate expense, and afford storage for the drainage of 12 to 15 square miles of mountain lands.

7. At Berkshire Valley a dam could be built across the Rockaway, by which a reservoir could be made, covering 1200 acres, 20 or 30 feet deep, and capable of storing the drainage of 30 square miles.

Annexed is a table showing the capacity and supply of the ponds here described, and the approximate cost of making them available by dam or otherwise.

TABLE.

NAME OF POND.	Area in acres.	Head or working depth, in feet.	Storage capacity in million gallons.	Drainage area in acres.	Minimum supply in million gallons.	Approximate cost of dam, &c.
Franklin Lake, . . .	94	5+ 0= 5	161	1000	327	$750
Rotten Pond, . . .	20 to 100	6+ 4=10	294	1200	392	1500
Negro "	100	5+ 4= 9	294	900	294	2000
Mud "	50 " 120	4+11=15	441	1600	523	6200
Tice's "	40 " 125	5+ 3= 8	261	800	262	1175
Shepherd's Pond, . .	90	4+ 6=10	294	1000	327	1150
Greenwood Lake, . .						
Macopin Pond, . . .	362	4+ 5= 9	1117	3200	1046	950
Hank's " . . .	80 " 120	6+ 5=11	431	2500	817	1310
Cedar " . . .	96 " 140	4+ 3= 7	274	800	262	860
Buck Mountain Pond, .	75 " 120	0+12=12	353	1600	523	2600
Dunker " .	125 " 800	5+ 5=10	1960	3200	1046	1400
Canistear " .	70 " 120	15+ 5=20	588	2000	653	2100
Timber Brook, " .	72 " 100	5+ 3= 8	196	800	262	3000
Stickle's " .	101	10+ 5=15	392	1800	589	2700
Split Rock " .	237	10+10=20	1307	4000	1308	1800
Durham " .	65 " 110	4+ 6=10	327	1200	392	4000
Green " .		0+ 3= 3	551	1920	627	600
Denmark " .	175 " 300	5+ 3= 8	462	1800	589	1000
Middle Forge " .	70 " 100	5+10=15	490	4000	1308	750
Dixon's " .	75	5+ 5=10	245	1200	392	1300
Shongum " .	125 " 165	5+ 5=10	473	1800	589	1200

The first column in the foregoing table shows the area of the reservoirs, both when drawn down and when filled. The second column, showing the available head, gives two numbers, the first of which shows the depth below the present surface to which the pond can be drawn, and the other gives the height above the present surface to which it can be raised, the sum of the two being the available vertical capacity.

The following table shows the approximate capacity of the artificial reservoirs which have been referred to:

TABLE.

LOCATION.	Area in acres.	Head or working depth.	Storage capacity in million gallons.	Drainage area in acres.	Minimum supply in million gallons.	Approximate cost of dams, &c.
Outlet of Mud Pond, .	100 to 125	10	290	3,000	981	$800
On Ringwood River, .	570	20	3,650	55,680	18,200	22,200
Near Hewitt Furnace,	75 " 80	10	245	1,300	425	600
West of Boardville, . .	100 " 150	10	320	1,000	327	1,000
Outlet of Stickle's Pond, .	80 " 100	8	261	3,000	981	500
Mount Pleasant, . . .	800	10	1,831	8,320	2,718	25,000
Pompton Furnace, . . .	292	6	573	94,720	31,000	5,000

Very large and capacious reservoirs can also be made in the valley of the Pequannock at Oak Hill, at Newfoundland, at Bloomingdale and at some other points, altogether sufficient to store the whole of the freshet waters of that stream.

A very. large reservoir can also be made on the Ringwood at Wynokie, by raising the old Furnace dam; or still better, by erecting a dam where the stream crosses into the eastern valley, for which an estimate is put into the table.

The Furnace Pond on the Ramapo, at Pompton, now covers 275 acres, and averages probably as much as 20 feet in depth; can be raised 6 feet more, and thus be made to store the surplus water from 148 or more square miles on that stream.

The time devoted to this work has not been sufficient to collect more details than those given above. But there are many other ponds known, and many other promising locations for storage reservoirs, in high and sequestered localities.

PLANS FOR SUPPLYING WATER.

Any plans for water supply for this district should be on a comprehensive scale; arranged so as to admit of enlargement equal to

any future need, and so carried out as to avoid unnecessary expense in anticipation of the future, or to construct any work that will need to be abandoned in after enlargements. There are now about 250,000 people supplied from the water pumped at Belleville, and in the heat of summer this year the daily consumption rose to nearly 25,000,000 gallons, which is 100 gallons for each inhabitant. It is not unlikely the person is now living who will see 1,000,000 inhabitants in this district. And the plan which is now adopted for water supply should be ample for the present, and capable of easy expansion to meet the wants of this coming people.

The plan of getting the Morris Canal water and its reservoirs, Lake Hopatcong and Greenwood Lake by purchase, has been frequently proposed. The water is unexceptionable in quality, sufficient in quantity with its present reservoirs to supply 35,000,000 gallons daily, and capable of having its supply enlarged indefinitely. The canal is 174 feet above mean tide at the head of Bloomfield Plane, which is only two or three miles from the water pipes of Jersey City and Newark, and it can be connected with the present water pipes, quickly and at moderate expense. It is objected that the canal is needed for its present uses; that it cannot be given up without great injury to many business and industrial interests and obligations; that it is questionable whether the open canal will answer for the conveyance of a winter supply of water, and if it should not, a pipe or conduit on its line would be long and expensive; and that the cost of the canal would be more than that of an adequate supply from some other source.

It has also been proposed to bring the water of the Rockaway from near Denville, mostly by natural channels, to near Morristown, and from there by conduit or pipe along the high ground back of Madison and Chatham, and across the Passaic valley, and then, by tunnel, to ground 300 feet high near Millburn, and from thence by pipes wherever needed. This would supply 60,000,000 gallons daily of good water, and with sufficient head for all present demands. The line, however, is long, expensive, and would divert some streams from their present courses.

This plan could be modified by taking the water at Morristown through the ridge to Loantaka Brook, and thence in the natural channels to Chatham, from which it could be taken at an elevation of about 200 feet through the mountain to near Millburn, and then

distributed by pipes wherever needed. This is a feasible plan. It would bring in the water from 180 square miles of water-shed, and could supply 100,000,000 gallons of good water daily.

A plan proposed and carefully studied out by L. B. Ward, C. E., of Jersey City, is to take the water of the Passaic at or near Page's dam, above Chatham, and carry it through the mountain by tunnel to Millburn, as in the last plan. The supply of water could be increased by connecting the head waters of the Raritan, and, if needed, by opening the channel from the Rockaway at Berkshire valley to the Black river, and from that across to Dead river and the Passaic again. More than 100,000,000 gallons daily could be supplied in this way.

The plan proposed by General E. L. Viele, of New York, to which reference was made in the report of last year, is to locate works at the end of the mountain, near Little Falls, where all the water from the Passaic passes, and by the auxiliary use of steam power to elevate all the water that may be needed to a high natural reservoir in the mountain at that place. From that reservoir water can be distributed to all the cities, towns and villages between the Orange Mountain and the Hudson river, in abundance, and at any height that may be required. The plan is feasible, and ample for the purpose, and the supply of water all that can be desired.

Another plan is to take the water at the head of Little Falls, where all the water of the Upper Passaic passes, and where the whole supply can always be controlled. If the water power at Little Falls can be purchased, it may be used to drive pumps which would raise the water sufficiently to carry it in a tunnel through the mountain at the Great Notch. This need not involve the raising of water more than 50 feet. The Falls are 157 feet above mean tide, and will have a height of 30 feet after they are cut down 7 feet, to allow the drainage of the flat lands along the Passaic above them. Seventy-five per cent. of this height can be made effective in raising water. 100,000,000 gallons run over the Falls daily when the stream is lowest, with an *effective* head of 22½ feet, which is sufficient to raise 45,000,000 gallons 50 feet high. This is enough for the daily supply for many years to come, and if a high service were required a smaller quantity could be pumped into a reservoir much higher. If the water power could not be secured, a gravity supply can be obtained at the same level, by going a little farther away. The

Rockaway River, at Boonton, is nearly 400 feet above tide; water can be taken there and brought along near the present line of the Morris Canal to the Hook mountain, and then along the mountain to near Mead's Basin, and from thence across the Passaic and to the mouth of the tunnel as before. The Pequannock, Ramapo and Ringwood can all be conducted on a high level to meet the Rockaway at Mead's Basin, from there to follow the same course as above mentioned. In this plan sufficient water can always be had by storage, no present uses are interfered with, and the place is the nearest of any to the points for distribution. Water could be advantageously taken from the Morris Canal at Little Falls, if the rights for it were obtained.

The cost of pumping by water power is much less than by steam. The Commission of Engineers, appointed by the Mayor of Philadelphia in 1875, to report on the present and future water supply of that city, for their estimates assumed "the cost of running the water power machinery, including all repairs and renewals, at three cents per million gallons, raised one foot high; and the cost of running the steam machinery, including repairs and renewals, at fifteen cents per million gallons, raised one foot high." The water for Newark is now raised 165 feet high by steam, and that for Jersey City nearly as much, and also by steam. At Little Falls the water is now 150 feet above tide, if raised 50 feet higher it would have as great an effective head as that now in the Newark or Jersey City reservoirs, and the cost of raising it by water power would be less than one-fifteenth as much. The cost for a supply by gravity is the interest on the first cost of the works. In either case, however, it is a fair and hopeful subject of calculation, as to whether the change to an unobjectionable supply of water cannot be made without much increase in the annual expense.

The Croton aqueduct, which is a brick conduit capable of delivering 110,000,000 gallons daily, cost $30 per lineal foot, and the cost at the present time would probably not vary much from that. Cast iron pipes, four feet in diameter, which are large enough for the present supply of either Newark or Jersey City, are estimated to cost, when laid complete, from $15 to $18 per foot.

Either of the plans mentioned will answer to bring an abundant supply of pure water for present and future wants, and at a cost less than that of the Croton water works for New York when she had no larger population than that to be supplied here. And still other

plans may be found on further examination, which will answer equally well. The one to be selected will be determined by financial considerations and engineering requirements, which will develop as the inquiries progress.

The supply of wholesome water is the first and important subject of this inquiry, but the question of expense is also of great interest, and it is not unreasonable to expect that though the first cost of works to supply water by gravity, or by pumping by water power, will be greater than the present works, the annual expense will be much less, and that an unexceptionable water supply may be had without increasing the burden of yearly taxation.

A plan has also been proposed by Andrew Clerk, C. E., of Jersey City, to take the water from the Passaic above Dundee dam, where it is at an elevation of 20 feet above tide water. Conduits properly laid from here would carry the water by gravity to the Newark or Jersey City pumping works, and from there it could be pumped up as it is now; or better for Jersey City the conduit could be carried from the dam direct to the foot of Bergen Hill, and then pumped up into the reservoir on top of the Hill. To prevent the pollution of the water by the sewage at Paterson, it is a part of the project to have intercepting sewers along the river banks in Paterson, which will conduct the sewage from that city along the valley, and discharge it into the river below Dundee dam.

The *map* of the Passaic water-shed, which accompanies this report, is intended to exhibit the various sources of water supply, and distribution for various cities and towns in eastern New Jersey. The reservoirs now existing are marked by horizontal lines; those which are proposed are marked by the streams in them. The small figures on the map show the heights of the surface, at the marked points, above mean tide, and may aid in the selection of lines of location for water pipes to supply different localities.

For these heights we are largely indebted to railroad and canal officers, who have given every facility for obtaining them from their records. Special mention should be made of the valuable contributions furnished to the list by R. C. Bacot, C. E., of Jersey City; F. H. McDowell, C. E., of the Montclair and Greenwood Lake Railway, Jersey City; J. W. McCulloch, Esq., of the N. J. Midland Railway; James Owen, C. E., of the Essex Road Board, Newark, and George H. Bailey, C. E., of the Newark Aqueduct Board.

The importance of preserving the waters of streams from pollution, is coming to be generally appreciated. At the session of the New Jersey Legislature in 1876, an act was passed "to prevent the willful pollution of the waters of any of the creeks, ponds or brooks of this State." Laws of New Jersey, 1876, p. 244. And the Parliament of Great Britain has passed an act entitled "The Rivers Pollution Prevention Act," 1876, applicable to England, Scotland and Ireland. It prohibits the polluting of any stream by solid matter, by sewage, by any manufacturer's waste or refuse, or by any mining products or poisonous wastes, and restricts the proceedings against them, which may be summary, to sanitary authorities. "Pollution of Rivers, 39 and 40, Vict. Ch., 75."

This action is a great step in advance of any previous legislation, and has been reached after very long and expensive investigations.

IRON ORE.

The continued depression of the iron manufacture throughout the year has been seriously felt by the mining industry of the State, not only in prolonging the quite general stoppage of mines and works, and in hindering all explorations, but also in further curtailing the operations of many individuals and companies, and thus reducing still lower the mineral production of the State. The ore mined in 1875 was considerably less than that of the preceding year. We have no statistics for the current year, but from a general observation of the mining districts, and the incomplete returns from a few parties engaged in mining and carrying ore, it seems highly probable that the aggregate for the year will fall considerably below that for 1875. It is hoped that we have "touched bottom" at last, and that as the general business of the country gets settled, even at low prices, the iron trade will soon get adjusted upon a firm basis, and create a steady demand for our best if not for all our ores. In such times of limited demand, with sharp competition and consequent low prices, there is a most urgent need of economy in all the details of mining—carrying and working up our ores. And our favorable location near the coal supply and the best markets are decidedly in our favor. These, together with the richness of many of our ores, ought to enable our miners to compete with other iron districts. The increasing consumption of steel makes a fair market for all

ores suited to the production of Bessemer pig metal, and this fact seems to urge the careful survey of our iron mining district to discover such ores. The location of some of these, in the northwestern or Pequest Belt, was quite fully given in the report for 1873, and in the subsequent reports for 1874 and 1875, and it does not appear necessary to do more now than to call attention to the facts and generalizations previously published, and to urge further exploration and examination, in the hope that these may result in valuable discoveries, not of *iron* ores only, but of those fitted to make steel.

ZINC ORE.

The zinc mines of the State, at Ogdensburg and Franklin Furnace, Sussex county, continue to be worked steadily, and their product from year to year does not appear to fluctuate so much as that of our iron ore district. According to a new business arrangement a considerable proportion of the ores mined at Franklin Furnace is sent to Bethlehem, Pennsylvania, for making oxide of zinc (*zinc white*). These large beds of rich ore, if worked vigorously, are capable of supplying a greatly increased amount, and at prices that can compete with any other zinc ore district in our country. And we look to these two localities as destined to be centres of mining operations which will add very largely to the mineral product of our State. An examination of maps and reports previously published by the Geological Survey, or a careful survey of the ground, will convince any one that these are moderate statements, and compel their belief. They are unrivaled in extent and richness.

COPPER ORES.

The copper mines of the State are all idle, and no further notes or descriptions are necessary. It may be in place to add that, as has been previously stated in full in reports on the ores of this metal, none of them were even really *very* promising, or ever worked with steady profit.

CLAYS FOR POTTERY AND FIRE-BRICK.

The fire-clay, stoneware-clay, and other beds of refractory and pottery materials, have shared in the general business depression.

The mining of fire-clay, *kaolin* and *feldspar*, used in the manufacture of fire-brick, has been greatly reduced in amount of products. The stoppage of so many of the older iron furnaces and works, and the large number of such new furnaces, has almost stopped the work of construction, and consequently there is only the very limited demand for brick necessary for keeping in repairs the small number of works in operation. And the clay mining industry appears to be more prostrated than even the iron mining. For stoneware and pottery there is a larger demand, and such clays find market.

MISCELLANEOUS NOTES AND ANALYSES.

1. *Magnetic iron ore* from lands of Thomas Haggerty, one mile east of Warrenville, Warren county. This ore was taken as an average of several tons raised from a small opening made in 1874. The observations on the ground, made with the dip compass, showed a long and quite broad *attraction*, running a little east of north. In the northernmost opening, whence this specimen was taken, the hanging wall is clean, and the ore on that side of the *vein* is rich. Towards the foot-wall side it is largely mixed with feldspar, quartz and hornblende. In the southern hole the ore was coarse crystalline, and here also mixed with a comparatively large proportion of rock.

The analysis gave the following results:

Metallic iron	56.40	per cent.
Phosphorus	0.21	"
Sulphur	0.05	"

There is nothing remarkable in the character of this ore. It is a new locality in the northwest or Pequest Belt.

2. *Magnetic iron ore* from Ten Eyck's mine, near the State line, Vernon township, Sussex county.

Several openings have been made here for testing the ground by Mr. F. Ten Eyck, of Warwick, New York. The ore is lean, but is remarkable for the large amount of quartz in it, and the absence of the other minerals so common to our magnetic iron ores. The quartz and magnetite alternate in thin layers, forming a moderately fine crystalline aggregate. A partial analysis showed that there was

about 50 per cent. of quartz in it. The metallic iron amounted to 33.91 per cent. The phosphorous was only .028 per cent. This low per centage of phosphorous is noteworthy, and more particularly this character associated with quartzose ore. This observation, mentioned in previous reports, receives in this an additional fact in its confirmation, tending to make this generalization of value. No ore has as yet been sent to market.

3. *Magnetic iron ore* from Squier's mine. The several openings thus named are on lands belonging to the estate of the late John Rutherfurd, a few rods east of the Greenwood Lake and Warwick road, and near the State line, West Milford township, Passaic county. The work of opening on this property was begun in January, 1875, under the direction of E. H. Wright, of Stockholm. The magnetic attraction was found to be steadily positive for a long distance, then negative for about 50 feet; then again positive to the end of the line, whose total length was 2,400 feet. The course of this line of attraction is north 38° 30′ east. Eight openings were made, including several cross cuts, which stopped at the ore and rock, and were sufficient to show the size of the *vein*. The average breadth of the ore in these several cuts and shafts, was found to be 12 feet. The largest opening was a drift on the *vein* running into a side hill, until the height of the breast was 78 feet. At the bottom of this open cut, there was eight feet of solid ore and ore forming the foot wall, so that its thickness was not here ascertained. A boring 14 feet into this wall was in ore throughout this distance. At the top of the hill, and at the breast, the removal of the earth and surface materials showed five separate veins, each about five feet in width. The dip, as obtained from the hanging wall, which is clean, is about 80° southeast. The other openings are shallow cuts, and pits sunk a little way into the ore and rock. On the foot-wall side of the vein there appear to be several *pockets* or smaller *veins* of ore, not connected with the main vein. The absence of any attraction, over the space between these two *lines* of ore, seems to show that they are distinct lines. One opening uncovered a breadth of 38 feet of ore, at a depth of 3 feet. The attraction was observed to extend over this, throughout an area of 400x60 feet. The ore contains varying quantities of feldspar, quartz, epidote and pyrite, mixed with the magnetite, but the average is moderately rich. Specimens of sur-

face ore, and from the deeper workings, were sent to the laboratory of the survey by Mr. Wright. Partial analyses of these show:

	1.	2.
Metallic iron	48.16	55.39
Phosphorus	0.14	0.067
Sulphur	3.02	1.74
Titanium	None	None
Manganese	None	None

1, is the surface ore.

2, ore from deeper part of working.

These figures indicate ore of good quality, and if the specimen 2 shall prove to be an average of the mine, it may be used in making Bessemer pig metal. About 1500 tons of ore have been mined. This mine was visited in December, but the most of details here given were communicated by Mr. Wright.

4. *Magnetic iron ore* from Stony Brook mine, sent to the laboratory of the Survey by the proprietor, M. J. Ryerson, of Bloomingdale. This mine is two miles southeast of Charlotteburg, and near the old Earle forge, in Pequannock township, Morris county. Ore was discovered here, and some mining done by the London Company prior to the Revolution. It was reopened and worked a little by Mr. Ryerson about sixteen years ago. There are five openings, of which the deepest is 30 feet. The *vein* is rather narrow, being only 2½ to 3 feet wide. It dips 60° south, 65° east. The analysis gave the following results:

Matter insoluble in acid	8.10	per cent.
Magnetite	89.33	"
Titanic acid	1.50	"
Phosphoric acid	Traces.	
Sulphur	None.	
Manganese	None.	

Or,

Metallic iron	64.69	per cent.
Phosphorus	Traces.	
Sulphur	None.	

These figures are quite unusual and remarkable in analyses of iron ores of this Highlands region. It is not only a rich ore, it contains nothing detrimental to the character of iron which may be made from it. It ought to do for steel. This remarkable character explains this notice of an old locality. Such ores are worthy of attention at all times, and particularly in these days of stagnation in iron mining. The analysis suggests further work upon this line for the determination of the capabilities of our ores, for it may be that in neglecting this we are leaving mines and ores which could be profitably worked.

5. *Nickel and Cobalt.* Two specimens of pyritiferous rock sent to the laboratory from Chester, Morris county, have been examined for nickel and cobalt, and found to contain small quantities of these metals. One of these was found on the farm of Wm. H. Sharp, between Chester and Peapack, the other on lands of John D. Evans, near Chester. The rock in both specimens holds the white pyrites, or marcasite, in very thin veins irregularly traversing it, and this mineral carries these metals, but in too small amounts for their profitable extraction. The Survey has received repeated notices* of the discovery of nickel ores, and it has made several examinations of such specimens supposed to contain working percentages, but so far they have proved to be nothing more than ordinary pyrite, with traces only of this metal. And from these it would seem as if this metal, as also cobalt, are not at all uncommon in much of the pyritiferous rock of the country. But these results do not argue against the probability of yet discovering [illegible] ores, and in some such form or combination as [illegible]. It may be proper to add here, that [illegible], the [illegible] ore of this metal, is [illegible] whiter than our common pyrite.

6. *Magnesian Limestone* [illegible] Furnace, Warren [illegible] analyzed carefully [illegible] iron. The results [illegible]

*Note.—Since the above was [illegible] has been received [illegible] and this contained a [illegible] by delicate chemical tests.

Carbonate of lime	50.3
Carbonate of magnesia	42.4
Alumina	0.3
Ferric oxide	0.9
Phosphoric acid	0.1
Silicic acid and quartz	5.5
Total	99.6

It does not differ materially from the average of the blue magnesian lime stones, of the northern part of the State, and is a true dolomitic stone. The phosphoric acid, which may yield its phosphorus to the iron made in using such stone, is comparatively small in amount, less than the average found in our magnetic iron ores and it ought to be a good flux in blast furnace work.

7. *Infusorial Earth.* Another deposit or bed of this earth was discovered lately, near Andover, Sussex county, and a specimen sent to the laboratory by E. Wright, of that village. The locality has not been visited. Other deposits have been reported, but nothing is known of them. There has been some inquiry for infusorial earth for making artificial stone and silicate of soda. It is also employed in the manufacture of dynamite or giant powder. Those interested in searching for deposits of this earth, or seeking for supplies, are referred to a notice of the Drakesville bed, and some general account of the occurrence, uses &c., of infusorial earth, on pp. 54–56, of the Geological Survey Report for 1875.

GEOLOGICAL SURVEY OF NEW JERSEY.

ANNUAL REPORT

OF THE

STATE GEOLOGIST,

FOR THE YEAR

1877.

TRENTON, N. J.:
NAAR, DAY & NAAR, PRINTERS.
1877.


GEOLOGICAL SURVEY OF NEW JERSEY
MAP
OF
NEW JERSEY
1877.
Scale
Glacial Drift.
EASTON
PHILADELPHIA
TRENTON
Plainfield
Somerville
Flemington
Lambertville
Princeton
Jamesburg
Freehold
Long Branch
Manchester
Burlington
Mount Holly
Camden
Gloucester City
Woodbury
Swedesboro
Glassboro
Woodstown
Salem
Vineland
Bridgeton
Millville
Mays Landing
Atlantic City
Tuckerton
Barnegat
Cape May C.H.
Cape May City
Morristown
Madison
Orange
Dover
Newton
Washington
Belvidere
Hackettstown
Perth Amboy
New Brunswick
Sandy Hook
RARITAN BAY
DELAWARE BAY
ATLANTIC
OCEAN
DELAWARE
PENNSYLVANIA
J. Rien, Lith.

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Board of Managers.

His Excellency, Joseph D. Bedle, Governor, and *ex-officio* President of the Board............Trenton.

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Hon. Andrew K. Hay............Winslow.

II. CONGRESSIONAL DISTRICT.

Hon. William Parry............Cinnaminson.
Hon. H. S. Little............Trenton.

III. CONGRESSIONAL DISTRICT.

Henry Aitkin, Esq............Elizabeth.
John Vought, M. D............Freehold.

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Thomas Lawrence, Esq............Hamburg.

V. CONGRESSIONAL DISTRICT.

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VI. CONGRESSIONAL DISTRICT.

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Thomas T. Kinney, Esq............Newark.

VII. CONGRESSIONAL DISTRICT.

Benjamin G. Clark, Esq............Jersey City.
William W. Shippen, Esq............Hoboken.

GEOLOGISTS.

George H. Cook, State Geologist............New Brunswick.
John C. Smock, Assistant Geologist............New Brunswick.

To His Excellency Joseph D. Bedle, Governor of the State of New Jersey, and ex officio President of the Board of Managers of the State Geological Survey:

SIR:—I have the honor to present my report on the work of the Geological Survey for the year 1877.

With high respect,

Your obedient servant,

GEO. H. COOK,

State Geologist.

REPORT.

INTRODUCTION.

The Geological Survey of New Jersey is carried on for the development of the natural resources of the State. In accordance with this view of its objects, geological investigations are working out the details of structure, composition, origin, age and location of the various rocks, earths and minerals found in the State; they are also showing the economic uses of our natural products, and presenting ways by which such products can be made most available for the State and its people.

Inquiries concerning marls, soils, ores, building stones, slates, limestones, &c., are pursued; also inquiries about water supply and drainage—as also those concerning agriculture and sanitary improvements. The making of accurate and detailed maps, which will show correct locations and distances, and also heights above the sea, is, in the absence of any maps of sufficient accuracy now in existence, a necessary part of the work, which has been satisfactorily begun. And collections of rocks, fossils, ores, minerals, building stones, limestones, slates, marls, clays, sands, peat and other useful products, are made and have been deposited in the Museum at Trenton, and in the cabinets of Princeton College, Rutgers College and Stevens Institute.

The work done during the year is described under the following heads, viz.:

1. The final report on the clay district of Middlesex county.
2. Exploration of the portion of the State covered by the glacial drift.
3. Examination of the deposits of shell marl, in Sussex and Warren counties.
4. Extension of the Coast Survey Triangulation over New Jersey.
5. Topographical survey of the country between First Mountain and the Hudson.

6. Drainage of the Great Meadows on the Pequest.
7. Laboratory work in the analysis of iron ores, limestones, marls, &c., &c.
8. Office work of Centennial Map, Museum of the Geological Survey, &c.

ASSISTANTS.

Prof. John C. Smock, Assistant Geologist, has been engaged in geological explorations of the glacial drift, the plastic clay and shell marl formations, and in office work connected with them, through the entire year.

Edwin H. Bogardus, Chemist, has been at work in the laboratory during the year.

Geo. W. Howell, C. E., has been occupied for a part of the year in the topographical survey of the country between First Mountain and the Hudson.

Prof. Ed. A. Bowser, C. E., has continued the coast survey triangulation in New Jersey during the summer and autumn.

EXPENSES.

The expenses have been kept strictly within the appropriation. The accounts have been regularly audited by a committee of the Board.

1. FINAL REPORT ON THE CLAY DISTRICT OF MIDDLESEX COUNTY.

This report, with the accompanying maps and sections, is now going through the press, and will be ready for distribution in a few weeks. It will make an 8vo. volume of 350 pages, and will be accompanied with a geological and topographical map, on a scale of 3 inches to a mile, which shows the location and elevation of all the clay pits that have been opened, and the outcrop of the different clay beds, as far as they are thought to be available; and by a general section, on a scale of 6 inches to a mile, which shows all the clay openings at their proper heights and in one plane. The explanations and illustrations of the work are such as to make them available for intelligent explorers and landowners, who are interested in the digging and sale of clay;

and the report will also help to make public the beds of rich fire and potters' clay of this district. In quality, for standing fire, there are no better clays in use, as is shown by the analyses and fire trials of these clays as given by comparison with the best of our own country and of England, Scotland, France, Germany, and Belgium.

Most of the pits opened are along the navigable waters of the Raritan river, Staten Island sound and Woodbridge creek, and none of them are more than two miles from docks and water carriage, and all are within 25 miles of New York. The amount to be obtained is enormously large. Ten thousand tons to the acre is not an uncommon yield, and single acres have yielded 40,000 tons, and there are hundreds of acres of such ground. For supplying material for fire bricks, gas retorts and other refractory wares, this district has advantages over any other in the whole country. It also supplies a large amount of clay for fine and common pottery. It is of the highest economic importance that the superior quality of these clays should be more generally known. Great quantities of excellent clay for making refractory wares have been and are still being wasted, from their valuable properties not being known. The manufacture of all kinds of articles from clay is just being fairly established in our country, and the most available materials to be used in carrying it on will all be in demand. There has been dug in a single year in the clay district described, 265,000 tons of fire clay and 20,000 tons of stoneware clay. There is no reason why this amount should not be quadrupled, and it is hoped that this report will help to make it profitable to begin this enlarged use.

2. EXPLORATION OF THE PORTION OF NEW JERSEY WHICH IS COVERED BY THE GLACIAL DRIFT.

The occurrence of loose and rounded rocks, stones and gravel on the surface, and of kinds of stones entirely different from the solid rock underneath, has been observed by every one who has traveled in the Northern States of our country. In the Southern States, gravel banks are occasionally met with, but the loose and rounded rocks and stones are very uncommon. So well marked is this difference that it is recognized as a fact that the diluvium or drift of the Northern Hemisphere did not extend

below about latitude 40° in our own country. The cause of this phenomenon has been variously ascribed to water, to floating ice and to glaciers. The study of glaciers in Switzerland and Norway, and in high northern and southern latitudes, has led most geologists of the present day to the conclusion that our great deposits of gravel, stones and loose rocks have been left in their present places by glaciers. That all the northern part of this continent has been covered by a thick body of ice, so thick, even in New Jersey, that it covered the tops of the highest mountains. That this immense mass of ice had a slow movement from the north towards the south, in which it scraped or tore off the earth and rocks from the rocky mass under it, grinding, grooving and smoothing down the rocky surface, and pushing forward, tumbling and rounding the fragments of stone and rock, and finally leaving them at the southern edge of the glacier, or wherever breaks in it may have allowed the loose materials to rest. This theory is consistent with observed facts. The terminal or southern edge of the drift is well and very plainly marked by a line of hillocks of mixed clay, sand, gravel, rounded stones and boulders of large size. The thickness of the ice is inferred from the fact that high hills and mountain tops are smoothed and grooved the same as the lower ground. The direction of the movement is proved by finding that the loose rocks and stones are always like the fast rocks which are north of them, and not like the rocks further south. The direction is further proved by observing the direction of the streaks, scratches and grooves in the worn rocks underneath, which are almost always in a southerly direction. The powerful scraping action of the moving glacier is further proved by our finding no disintegrated or decomposed rock in the country where the drift occurs, while it is very common and a marked feature of the country south of it. To those who are not yet prepared to accept this theory, as well as for those who do, it will be convenient to look at the details as they are arranged under these several heads.

Beginning on the eastern side of the State on the north side of the Raritan, at Perth Amboy, the line of Short Hills extending from that place to the First Mountain, and passing just north of Metuchen, Plainfield and Scotch Plains, marks the southern edge of the drift. Between the First and Second Mountains it fills the whole valley for less than a half mile south of the Morris

and Essex railroad. Between Second Mountain and Long Hill, the deposit of clay, gravel and boulders runs just south of Summit, and crosses the Passaic a little above Stanley. From Long Hill to Morristown the deposit of gravel and boulders forms a ridge which is just south of the Morris and Essex railroad, and has its southern foot marked by the Great Swamp and Loantika brook. From Morristown westward across the ridges of the Highland range of mountains, the terminal deposit is not so regular in its occurrence. It can, however, be seen at Dover, and is very plainly marked where it crosses the valley of the Musconetcog, about a mile northeast of Hackettstown. Thence it crosses the mountain in a very irregular but well marked line of hills to the valley of the Pequest at Townsbury. From there onward by the southwest end of the Jenny Jump mountain and Butzville, it extends on to the Delaware below Belvidere. The portion near the Delaware shows the gravel and boulders very plainly, but it appears to have been washed and otherwise modified by floods or great bodies of water descending in that valley. The whole line of this moraine is remarkable plain and well defined. It is not as distinctly marked across the Delaware in Pennsylvania, but on the east it shows very plainly across Staten Island, where its eastern end forms one side of the Narrows, and furnishes the location for Forts Tompkins and Wadsworth, and on Long Island its western end marks the other side of the Narrows, and is the site of Fort Hamilton. Thence it runs eastward, furnishing the sites for Greenwood Cemetery and Prospect Park, and extending along the north side of the island for 40 or 50 miles. Its course finally changes a little towards the south, and it reaches the south side of the island a few miles west of Southampton. This well marked line of hills of glacial drift is 150 miles long. The most southerly point reached in the whole distance is Perth Amboy, which is in latitude 40° 30′. Across New Jersey the line is not exactly east and west, but appears to deviate towards the north, the deviation being greater somewhat in proportion as the ground is more elevated.

The hillocks of stones, gravel and earth which together made this long chain, have every appearance of piles of debris which have been thrown down without order; and without the presence of water to sort or arrange the various materials. The hills join each other in such ways that basins without outlets are found so

frequently as to make lakes, ponds, and marshes a characteristic feature of countries covered by glacial drift, and whenever these hills are cut into, so as to show their structure, it is found that they are not stratified, but that the clay, sand and boulders are all mixed in a confused mass.

These hillocks, however, are not confined to the terminal moraine mentioned, but are irregularly scattered over all the country north of it, and to name them would require a long list. There is not a railroad crossing the district which does not cut them in many places. The Morris canal crosses from Montville to Hook Mountain on one. They can be seen all along the west foot of the Palisade Mountains and Bergen Hill. At Newark they make the bluff bank of the Passaic. They make the beautiful hill on which is the cemetery at Paterson. The Plains near Morristown are only drift hills which have been somewhat leveled on top by water. The remarkable bank across the valley of the Wallkill at Ogdensburg is only a mass of drift. A mass of glacial drift filling the valley of the Pequest has dammed the stream and made the marsh, which is known as the Great Meadows, and a similar dam of glacial drift across the Wallkill at Hampton, in Orange county, N. Y., has caused the water to set far back into Sussex county and made the Drowned Lands which cover a large tract of the very best land in those counties.

The top of the Blue Mountain, in Sussex and Warren counties, which is the highest land in New Jersey, being from 1500 to 1800 feet high, shows marks of glacial action everywhere. High Point which is 1799 feet high is smoothed as completely as the rocks in the valley, and a boulder 4 feet in diameter rests on its very highest point. The crests of the Highland ridges as well as their sides are all worn smooth, and boulders of the largest size are found resting on their tops. There is an immense mass of boulder clay at Stanhope, at an elevation of 950 feet, which has been cut through by the Morris and Essex Railroad.

The trap ridges known as the Palisades and the First and Second Mountains are all worn smooth to their tops as if the ice had thickly covered them.

It is only when near the southern border of this drift area that the thickness of the ice appears to have been insufficient to cover the crests of the mountain ridges. On all the ridges which

its terminal moraine crosses, the line has fallen back towards the north.

The following tabular statement of the elevation of various places, on the terminal line of the drift, and their distances north of the parallel of 40° 30' of N. L. may give some hint as to the probable thickness of the immense body of ice which brought down this mass of stones and earth:

	Elevation in feet above tide water.	Distance north in miles.	Rise per mile. Feet.
Perth Amboy	0	0	
Feltville, 1st Mountain	400	12	33
Second Mountain, 2 miles south of Summit	440	14	31
Morris Plains	700	22	32
Hills south of Dover	900	22	41
Hills west of Hackettstown	750	24	31
Townsbury	600	22	27
Mountain west of Townsbury	900	24	38
Mount No-More	750	21	36
Roxburgh	680	20	34
Average slope on rise per mile			34

If we assume, as facts appear to warrant, that the great glacier which covered this continent from 40° 30′ northward, had its upper surface nearly uniform, and rising towards the north at the rate of 34 feet per mile it would everywhere north of the terminal line have a thickness sufficient to overtop the highest land in the State, as its marks show that it did. The High Point on the Blue Mountain near the New York boundary is 1800 feet high, and has glacial marks and boulders on its top. It is 58 miles north of the parallel mentioned, and a rise of 34 feet per mile would make the thickness of ice there 1972 feet, which is 172 feet above the top of the mountain.

As this becomes the means of measuring the thickening of the ice from its southern and thin edge, towards the north, it is a matter of some theoretic interest. The total thickness, however, judging from the worn rocks on the higher mountains in New York and Pennsylvania, must have been at least 4,000 or 5,000 feet.

That the movement was from the north, is inferred from the

mineral composition and structure of the rocks and stones found loose in the drift, and by which a practiced eye can identify them and tell their parent rock. At Jersey City the boulders are mainly of trap rock, from Bergen Hill and Weehawken, altered red-shale from Weehawken, an occasional block of serpentine from Hoboken, and of gneiss from the country further north. Among the boulders at the Short Hills, near Metuchen, can be found masses of granite from the Highlands, 20 or 30 miles off, boulders of Green Pond mountain conglomerate from beyond Dover, and perhaps beyond the State line; occasionally, too, are found masses of sandstone containing fossils from the Oriskany rocks, either at Greenwood lake or beyond the Blue mountain, and all mixed in with an abundance of red sandstone from the underlying or adjacent rocks. Boulders of limestone, of great size and in large numbers, are found along the northwest slopes and on the tops of the Highland ridges, south and southeast of the limestones of the Kittatinny valley, while they are very uncommon in the country east of those mountains. Rounded masses of magnetic iron ore are found scattered sparingly over the country, to the south of the mountains in which the iron mines are found. In the valley of the Walkill, at Sparta, and even much further south, boulders of franklinite and zinc ore, some of them weighing many tons, are found lying on the surface or imbedded in the earth. They are evidently from the zinc veins at Stirling Hill or Mine Hill, six and eight miles away. At Ogdensburg, on the bank of a glacial drift, which is in the valley just east of Stirling Hill, boulders of the darker-colored franklinite and zinc ore, peculiar to the zinc vein at Mine Hill, are found among the stone and gravel that make up the bank. No such boulders are found north of these zinc veins. Like all the loose materials that can be identified anywhere in this whole area covered by glacial drift, they have been moved in a southerly direction. The parent rock, from which they were torn, is further north.

The scratches and grooves in the surface of the solid rock, mark the direction of the moving mass more accurately. They are to be found on masses of hard rock which have been covered with earth or soil, and are common on all the azoic, paleozoic and trap rocks of the district. They are not common on the

triassic red sandstone. Rocks, which have been long exposed to weathering agencies, do not show them.

These scratches, which are mostly parallel, have evidently been made by fragments of hard and tough stone, which have been driven over them while imbedded in some heavy and solid mass.

The following is a list of these scratches. They were mostly taken this year, the observations were made with a good pocket compass. They are arranged for the different ridges on which the observations were made; and as most of the ridges have a direction of northeast and southwest, and the scratches cross obliquely from the north to the south side, those on the north slopes are arranged separately from those on the south, so as to show whether the ridges have caused any change in the direction of these marks, and of the agency which produced them.

Directions of Glacial Markings, Magnetic Bearings.—Northwestern slope of Kittatinny, Blue or Shawangunk mountain, and valley west to the Delaware.

S. 35° W., half a mile east of Carpenters Point, near Greenville road, New York, on Cauda galli grit.

S. 80° E., Greenville turnpike, on Onedia conglomerate.

S. 75° E., Greenville turnpike, on Oneida conglomerate, farther east.

S. 65° E., Greenville turnpike, on Oneida conglomerate, still farther east.

S. 58° E., Greenville turnpike, on Oneida conglomerate, still farther east.

S. 60° E., Greenville turnpike, on conglomerate, summit of mountain.

S. 45° E., Port Jervis and Coleville turnpike, on conglomerate, one mile west of summit.

S. 65° E., Port Jervis and Coleville turnpike, back of road to High Point.

S. 75°–80° W., on High Point, conglomerate rock.

S. 70°–80° E., on Port Jervis and Coleville turnpike, one-quarter of a mile east of last station.

S. 85° W., on Port Jervis and Coleville turnpike, a few rods east of last point.

S. 80°–85° E., near Hornbeck's mills, Montague, on Cauda galli grit.

S. 45° W., on Peters Valley and Culvers Gap road, on Medina sandstone, one-quarter of a mile from road to Newton.

S. 50° W., near Big Flatbrook, on Peters Valley and Newton road, on Medina sandstone.

S. 48° W., on Peters Valley and Newton road, half a mile east of brook, on Medina sandstone.

S. 50° W., on Peters Valley and Newton road, still farther east, on Medina sandstone.

S. 45° W., on Peters Valley and Newton road, one-quarter of a mile west of road to Walpack, on Medina sandstone.

S. 18° W., Newton and Flatbrookville road, west of summit, on Medina sandstone.

S. 10° W. and S. 20° W., Newton and Flatbrookville road, on west slope of mountain, on Medina sandstone.

S. 16° W., mean, Newton and Flatbrookville road, on west slope of mountain, on Medina sandstone.

S. 18° W, Newton and Flatbrookville road, on west slope of mountain, near old school house, on Medina sandstone.

S. 20° W., Newton and Millbrook road, east of top of mountain, conglomerate.

S. 16° W., Newton and Millbrook road, on top of mountain, conglomerate.

S. 40° W., Flatbrookville and Millbrook road, down on slope, Medina sandstone.

S. 30° W., Flatbrookville and Millbrook road, down on slope, Medina sandstone.

S. 25° W., Flatbrookville and Millbrook road, Medina sandstone.

Southeastern slope of Kittatinny Mountain.

S. 30° W., on slate, one mile north of Coleville, on Port Jervis turnpike.

S. 80° E., on slate, southwest of Long pond, and near Newton and Walpack road.

In Kittatinny Valley and western foot of Highlands.

S. 30° W., on zinc vein, near Hamburgh road, at Franklin.

S. 10° W. and S. 20° W., on white limestone, along railroad, between Franklin and Ogdensburg.

S. 35°–40° W., on slate, in Fredon road, at Newton.

S. 35° W., on slate, Newton and Millbrook road, one mile west of Stillwater.

Southwest, top of slate ridge, Johnsonsburg and Marksboro road.

South, conglomerate at Alamuchy.

S. 20° W. and S. 30° W., on gneiss, east of Nelson Cummins, Great Meadows.

S. 5°–10° E., on sandstone, near Larason's bridge.

S. 30° E., on gneiss, eastern slope of Jenny Jump mountain, Danville and Hope road.

S. 15° W., on gneiss, on west slope of mountain, west of Warrenville.

S. 12° W., on gneiss, on Carrington and Longbridge road, west slope.

S. 30° E., on gneiss, on Carrington and Longbridge road, east slope.

On various ridges of the Highlands.

S. 5° W., on gneiss, Sparta mountain, half a mile northwest of Woodport.

S. 20° W., on gneiss, Stockholm, lower forge.

South, on gneiss, Green Pond road, west of Lyonsville.

S. 15° W., on gneiss, near Greenville school house.

S. 10° W., on conglomerate, summit of Copperas mountain.

S. 30° W., on conglomerate, western slope of Green Pond mountain, west of Green Pond.

On First, Second and Third Mountains (trap ridges.)

S. 30° W. and S. 40° W., in gap, west of High mountain, Second mountain range.

S. 80° W., Paterson and Pompton road, top of Second mountain.

S. 80° W., Paterson and Pompton road, just below and east of summit.

S. 70° W., 75° W. and 80° W., Paterson and Pompton road, on east slope of same mountain.

S. 80°–85° W., Paterson and Meads Basin road, Second mountain top.
S. 30° W., Paterson and Pompton road, on southern slope of Second mountain.
S. 25° W., Paterson and Pompton road, near foot of south slope.
S. 8° W., Paterson and Pompton road, foot of mountain, three-quarters of a mile from furnace.
S. 15°–20° W., Pompton furnace, near knife factory.
S. 75° W., Paterson, south of Garret rock, First mountain.
S. 75° W., Paterson, near Morris canal, on Little Falls road.
S. 40° W., Second mountain, northwest slope, near Passaic and Essex county line.
S. 48° W., on west slope of Second mountain, on Mt. Pleasant turnpike.
S. 48° W., on top of Second mountain, on Mt. Pleasant turnpike.
S. 50° W., on Second mountain, southeast slope, Centreville road.
S. 25° W., on Hook mountain, road crossing to Beavertown, northwest slope.
S. 40° W., on Hook mountain, near Beavertown.
S. 60° W., on Hook mountain, south of peat works, north slope.
S. 65° W., on Hook mountain, west slope.
S. 55° W., on Hook mountain, south end.
S. 60° W., on First mountain, near Eagle Rock.
S. 58° W., on First mountain, on west side of summit.
S. 72° W., on First mountain, on northwest slope, near foot, Centreville road.
S. 48° W., on First mountain, on rock cut half way up mountain, Centreville road.

Palisade Mountain.

S. 10° W., on High Torn, Haverstraw.
S. 20° W. and S. 30° W., in gap east of High Torn and south of Haverstraw.
S. 20° E., one-quarter of a mile northwest of Alpine, southeast of Closter.
S. 25° E., on summit, at Alpine.
S. 30° E., summit of mountain, on road from Cresskill to Huyler's Landing.
S. 15°–20° E., half a mile east of Cresskill, on west slope.
S. 18° E., on road from Englewood to Palisade Mountain House, near top.
S. 30°–40° E., on road from Englewood to Palisade, top of mountain.
S. 35°–40° E., in front of Palisade Mountain House.
S. 65° E., in front of Palisade Mountain House.
S. 25° E., Leonia and Fort Lee road, near Fort Lee.
S. 20° E., top of bluff, north of Fort Lee.
S. 40° E., on Palisade avenue, north of Guttenburg and English Neighborhood road.
S. 20° E., near Guttenberg brewery.
Southwest, one mile northeast of New Durham station, foot of mountain.
S. 10° W., one-quarter of a mile southeast of Homestead station, foot of hill.
S. 20° E., new reservoir on hill, at Hudson city.
S. 10° E., west end of Delaware, Lackawanna and Western tunnel.
S. 25° E., near east end of same tunnel.
S. 20° E., at east end of same tunnel.
S. 25° E., at point of rocks, Pennsylvania Railroad.
S. 25° E., south side of Montgomery avenue, Bergen Hill.
S. 42°–45° E., Montgomery avenue.
S. 20° E., west end of cut of Newark and New York Railroad.
S. 20° E., near Bergen avenue, Newark and New York Railroad.

S. 25° E., near Jackson avenue, Newark and New York Railroad.
S. 35° E., on railroad, 100 yards east of last station.
S. 35°-37° E., at the east end of cut for Newark and New York Railroad.
Southeast, at Avenue C, near Morris canal, Bayonne city.
S. 10° W. and S. 15° W., Newark bay shore, near Saltersville dock.
S. 15°-20° W., Newark bay shore, a little south of Saltersville dock.

The directions given in this table can be classified as follows:

1. *Approximately East and West*—
High Point, Blue, or Kittatiny, Mountain.
Blue Mountain, western slope, Greenville turnpike, New York.
Hornbeck's Mills, Montague, Sussex county.
Eastern slope of Blue Mountain (on slate) southwest of Branchville, Sussex county.
First Mountain, Paterson.
Second Mountain, west of Paterson, (road to Pompton).

2. *Southwest*—
Blue Mountain, western slope, Walpack township, Sussex county.
Blue Mountain, western slope, west of Culver's Gap, Sussex county.
Blue Mountain, western slope, Pahaquarry township, Warren county.
Blue Mountain, western slope, near Delaware Water Gap, Warren county.
On gneiss slope, east of Nelson Cummins, east of Great Meadows, Warren county.
On slate ridge, Newton, Sussex county.
On zinc vein, Mine Hill, Franklin, Sussex county.
In Walkill valley, Ogdensburg, Sussex county.
Near Marksboro (on slate ridge), Warren county.

Palisades Mountain (Bergen Hill), west slope, south of Pennsylvania railroad.
First and Second Mountains, west of Orange.
Second Mountain, near High Mountain, north of Paterson.
Torn Mountain range, Haverstraw, New York.

3. *Approximately South, (S. S. E. and S. S. W.)*
   South. Allamuchy, Warren county.
   South 15° west. West of Warrenville, Warren county.
   South. Near Lyonsville, Morris county.
   South 10° west. Copperas Mountain.
   South. Temple's store, Stockholm, Passaic county.
   South 10° west. Torn Mountain, Haverstraw, New York.

4. *Southeast—*
   Carrington, Warren county.
   Eastern slope of Jenny Jump Mountain, Hope road.
   Palisades Mountain and Bergen Hill, excepting foot of ridge along Hackensack Meadows and Newark Bay (see 2).

A remarkable characteristic of the glacial drift district, is the absence of the original earth and disintegrated rock from the surface of the country. Wherever drift is found, the underlying rock is generally solid and unchanged, and if of sufficient firmness is worn smooth and marked with fine parallel streaks or coarser scratches, and covering it is the drift material of mixed clay, loam and sand, with stones and boulders of sandstone, conglomerate, limestone, slate, granite, gneiss, hornblende and quartz rocks, such as constitute the fast rock in a great expanse of the country northwards, and the soils are of the same mixed character.

South of the glacial drift, few boulders are found. There are a few places like that on the New Jersey Central Railroad, a mile above Annandale station, or like that at Kingston on the Delaware and Raritan Canal, where glacial drift with boulders is seen. These may have been formed by local glaciers of small extent; and there is a belt of country, a few miles wide, immediately south of the glacial drift, in which numerous cobble stones and some boulders of quartzose rock are found. These stones are of smooth and in many cases of shining surface, and so different in appearance and material from those of the glacial drift that they can be recognized at a glance. Their origin is not known at present. They must belong to some older drift deposit of which we have not yet sufficient facts to furnish any connected account. But, generally, the country south of the glacial drift is covered with soil made from the rock immediately under it,

and mostly from its decay and the removal from it of some of its more soluble constituents. On the mountains in Warren, Hunterdon and the southern part of Morris county, the gneiss rock is so decomposed as to make a good soil, free from boulders quite to their tops, and where railroad cuts are seen, as in the New Jersey Central near High Bridge, or the approaches to the Easton and Amboy railroad tunnel near Bethlehem, the rock is so soft as to be easily cut into by the steam excavator.

The limestone in the valleys of Morris, Warren and Hunterdon is only covered by a fine yellow soil without boulders, which appears to be composed of the impurities of the original limestone rock, and to be left in its original place as the lime has been slowly dissolved out in the course of ages. This soil is entirely different from that in the limestone valleys of Sussex where drift deposits cover the rock to a considerable extent.

Over much of Middlesex, Somerset, Hunterdon and Mercer counties, which are underlaid by red sandstone and shale, the soil is nothing but the rock disintegrated, and there is no well marked worn or smoothed surface where one ends and the other begins.

The trap rocks too, which on the Palisade range and the ranges west of Newark, are everywhere worn and scratched on their upper surfaces, are in Rocky Hill, Sourland Mountain, and the south end of the ranges west of Newark, entirely free from such marks of wear, and the soil on them is only the remains of the disintegrated trap rock.

As the marl and tertiary deposits further south are earth and not rock, the worn surfaces would not expected; but the soils on them are the same as the deposits themselves. To this may be excepted the superficial differences produced by rains, weather and other atmospheric agencies, and older diluvial deposits.

The influence which this peculiar distribution of the glacial drift has upon the State is both interesting and important. It is seen in the differences of surface, in the collection of water in ponds and lakes, in the size of farms, in the different objects of profitable farming, and in the distribution of mixed industries. The rolling ground and rounded hillocks which form so characteristic a feature of the drift region are unknown in the country further south. Ponds and lakes so common in all northern countries are not found where glacial drift does not exist. They

occupy the basins between the hillocks which have been formed by heaps of stone and earth which have been dropped pell mell from the ends, or sides or crevices of the glaciers. Such basins are found everywhere in the glacial drift area, and can be numbered by hundreds. Some are found which are too open in the bottom to hold water, but most are filled and form beautiful lakes and ponds.

The more even and uniform surface south of the drift area enables farmers to work with less of broken and waste ground and fewer irregular fields, so that tillage is carried on more rapidly and cheaply, and more of farm crops can be got from a given area On the contrary, grass and grazing are best adapted to the drift soils, and the mixed industries of mechanics, manufacturers, &c., have been more generally engaged in on them than on other soils.

The map at the beginning of this report shows the extent of the glacial drift in New Jersey. To give the details of its distribution the location and shape of its numerous hillocks, ridges and basins, requires much further study and the construction of full and accurate topographical maps. It is hoped that another year will enable us to show some completed work in this interesting department of geology.

The beds of stratified drift, at various places in the valley of the Delaware, south of the line of glacial drift, bear marks of having originated from the action of water. The boulders and cobble stones are all water worn, and round, and are not scratched or streaked. They have all come from places farther north in the valley and have been moved and deposited by powerful currents. There are to be seen in the railroad cuts near Trenton, where the exposure of this kind of drift is very fine, boulders of gneiss, from the rock near; of red sandstone from the country just north; of trap from Lambertville; of altered shales from near the trap; of conglomerate from New Milford; of magnesian limestone from the valleys of Warren county; of conglomerates from the Blue Mountain, and of cherty and fossiliferous limestones from the Delaware valley north of the Water Gap. The gravel consists largely of quartz but it contains numerous fragments of red shale, and black slate.

In the edge of the bank of this bed of gravel and boulders, a mile or two below Trenton, Dr. C. C. Abbott has found rude

stone implements of a very ancient date. He has published an account of them, and is disposed to assign them to an age older than the glacial drift. The circumstances in which they are found on the edge of a gravel bank, where they might have fallen down from the top or near it, precludes that positive proof of their true position and age, which is needed before coming to a satisfactory conclusion.

It is very desirable that the subject to which Dr. Abbott has given so much time and attention, should be more thoroughly illustrated by specimens collected from all places where the Indians or other early inhabitants, have deposited them, and also that careful note should be made of the locations where found, the depth beneath the surface, the material in which they are buried, and all particulars which may help to a full understanding of them.

3. EXAMINATION OF THE DEPOSITS OF SHELL MARL IN SUSSEX AND WARREN COUNTIES.

Shell marl, or as it is sometimes termed "white marl," occurs at a large number of localities in Sussex and Warren counties. The deposits of this marl belong to the most recent of the geological formations, and some of them have been formed during the historic period. Consequently the deposits are found resting upon the most recent clays, gravels and sands of the modified drift. In fact nearly all of the localities are in marshes, or in and around ponds which are in these stratified drift beds. This is especially true of the numerous deposits between Newton and Hope along the valleys and waters of the Paulins Kill and Pequest and their tributaries. Generally, this marl occurs in limestone districts, but there are exceptional localities, as that of Roe pond, on Pochuck Mountain, and that on the Williams farm, south of Vernon, in Sussex county. Lime, or calcareous matter, may have been a favoring condition, and essential, but not necessarily so the limestone rock. Other rocks may have furnished a sufficient quantity of this element to the waters in which the fresh water mollusca lived and whose shells yielded the material for the marl.

All the deposits are in basins or small valleys, which were at first filled with water, or sufficiently wet to sustain these forms

of life. It seems probable that at first these were more open at the bottom and dry, though without any natural outlet. In the course of ages the wash from the slopes about them lined them with a clayey sheet, or puddling, which afterwards held the water. In this manner large and small sink holes gradually became pond holes and little pond basins, and these latter became the abodes of the several kinds of mollusca, whose remains make up the marl. The most common of these were the Limnea valvata, Planorbis and Cyclas. These lived in the shallow waters around the shores of these ponds. The succession of life left a multitude of little shells, which, through the action of waves and other accidents, were ground to pieces and formed the white, pulverulent, chalk-like mass. The marl, by the slow but steady accumulation of centuries, rose and extended itself until in some places the whole pond or basin was filled and there was no space left for the waters, or only for the drainage in very wet seasons. Following this filling in process, came the growth of grasses and plants suited to such wet grounds. These, by their decay, formed the peaty earth or muck so constantly found over these marl deposits, or around the borders of the ponds. And we now find every stage of the process going on, from the wet basin with these living shells and very little accumulation of calcareous matter, to deposits which are now dry during the greater part of the year and in which no living animals can be found and comparatively few well preserved shells. They are extinct in such localities and the work of accumulation is at an end. In still others the pond remains, but encircled by a bed of marl whose area greatly exceeds that of the water, and which occupies the site of the old pond. Such seems to be the order of progression and the origin of these deposits.

From the list given below, it will be observed that they are numerous in the valley of the Delaware, west of the Blue mountain, but mainly confined to a small part of Montague and to Sandyston townships. In the Kittatinny valley they are numerous along the Pequest and Paulinskill, particularly in the southeastern part of that valley, between Newton and Hope. In Green township, Sussex county, nearly every little basin is partly filled by this marl, and it is in most of the ponds. But it is not at all likely that these localities are all which can be found. Explorations will doubtless discover very many additional de-

posits about the many little ponds and lakes, and in the numerous peat bogs of that valley.

It will be observed that these deposits are all north of the limit of the moraine drift. This is to be expected. In a country perfectly drained, with no lakes, ponds or pond holes, these accumulations could not take place. Hence they are not to be sought for south of that line.

The composition of some of the best specimens, and such as represent large bodies of the marl, appear in the following partial analyses.

	Carbonate of Lime.	Carbonate of Magnesia.	Sand and Clay.	Water, Vegetable Matter, &c.	DESCRIPTION.	OWNER AND LOCATION.
1	98.33	....	0.90	0.67	White, pulverulent; no vegetable matter.	Job J. Decker, Andover, Sussex county.
2	88.86	....	9.96	2.16	Precipitate from water, white.	Benjamin Van Syckle, Peters Valley, Sussex county.
3	97.73	....	0.60	1 59	White, dense and fine.	Abm. M. Cooke, Shiloh, Warren county.
4	95.34	2.18	.98	1.50	Surface marl, white, solid and fine.	Abm. M. Cooke, Shiloh, Warren county.
5	96.32	1.57	1.16	.96	Drab-white, fine and with shells.	Daniel M. Howell, Hunts Mill, Sussex county.
6	92.25	2,98	1.56	3.21	White, pure, some grass roots.	White pond, Marksboro, Warren county.
7	89.87	2.29	.97	6.87	Ash-colored, many shells, light.	Henry S. Cook, Hope, Warren county.
8	96.54	1.47	2.05	0.00	White, very fine, medium density.	Martin Drake, Newton, Sussex county.
9	84.52	1.76	8.46	5.26	Surface marl.	Martin Drake, Newton, Sussex county.
10	90.18	0.00	9.75	....	White, very dense, thick shells.	Sink pond, near Lincoln, in Warren county.
11	99.04	0.00	.55	0.41	White, very light, pure.	Jacob Voss, near Lincoln, in Warren county.
12	68.73	0.00	23.99	7.28	Dark-colored shells and vegetable matter.	Isaac Bonnell, Montague, Sussex county.
13	94.75	0.00	.71	4.54	White, very light, pure.	White pond, Monroe Corners, Sussex county.
14	64.20	0.00	16.21	16.59	White shells and clay.	Francis Layton, Centreville, Sussex county.

These marls were tested for phosphoric acid, but not enough was found to weigh. Two specimens were analyzed for ammonia; one, which was a white one, in which none could be found, the other was No. 12, which contained only 15–100 of one per cent.

Shell marl has been found in the following places in Sussex and Warren counties:

1. Roe Pond. This deposit of shell marl is in Vernon township, Sussex county, and three-fourths of a mile south of North Vernon, or Glenwood P. O. The pond has an area of about 15 acres. The marl is found on all the shore line and is covered by a layer of

black muck one to two feet thick. By opening the gates in the dam at the outlet the water can be lowered and the marl easily reached. Some of it has been dug at the north end of the pond and used by J. S. Carpender. The *Parnassia Caroliniensis* was observed here growing in the marly soil.

2. Williams Farm, 4 miles south of Vernon, Vernon township, Sussex county. The extent of this deposit was not learned. The marl has not been dug, excepting as cut in ditching the meadow. The locality is quite exceptional, being in a gneiss rock district.

3. Black Creek Meadows, Vernon township, Sussex county.

4. Meadows east of North Church, Hardiston township, Sussex county.

5. Fowler Estate Farm and Mud Pond, Hardiston township, Sussex county.

6. Lane's Pond, Sparta township, Sussex county. The shells are seen about the shores of this pond, but no marl of any extent. It may be found deeper, or this may be a locality where the formation has just begun.

7. White Pond, Germany Flats, Sparta township, Sussex county. Marl occurs on the shores of this sheet of water and under much of the southern end of the pond. The area of the pond and marl shores is about 40 acres. The outlet is connected with Mud Pond and that with Lane's Pond. On account of the marl being mostly below the level of the water it is very wet and not so easily taken out, excepting in a very dry time.

8. Drake's Pond, near Newton, Sussex county. The pond in and around which this marl deposit occurs, has an area of 7 or 8 acres. It is in the magnesian limestone rocks. The maximum depth of the pond is 36 feet. The thickness of the marl is not known. It is, however, of workable extent and the outlet could be easily lowered 10 or 12 feet, so as to drain off much of the water and leave the shores dry. As it is only a few rods from the Sussex railroad, this marl locality has advantages of accessibility.

9. White or Davis Pond. Shell marl occurs in the meadows around and in White pond, near the Newton and Andover road and two miles north of Andover. The deposit is in a blue, magnesian limestone belt. It has an area of several acres. It is

very wet meadow, and drainage is not easily effected. The thickness of the marl was not ascertained.

10. DECKER'S POND.—This locality is one mile southwest of Andover, Sussex county. There is about ten acres of meadow south of the pond, in addition to the latter, in all of which the marl occurs. In the meadow it forms the surface over a considerable area. On the sides of the deposit there is some muck covering it. Some borings, made quite recently, found a thickness of twenty feet. This deposit is large and accessible at all seasons, although at times it is wet, and the drainage cannot be easily improved. Limestone rocks bound this deposit on the west; on the east there are gneiss and white limestone.

11. WILLIAM WOLF'S FARM, TROUT BROOK, Green township, Sussex county. Locality unexplored.

12. J. COLLINS DRAKE'S FARM, SOUTH OF REDING'S POND, Green township, Sussex county. The marl at this place is so deeply covered by muck that its extent has not been ascertained. There are several acres of the wet basin, all of which may be underlaid by it.

13. JOHN H. AYRES' MEADOWS, near Lincoln, Green township, Sussex county. This meadow occupies the site of an old pond. The marl is covered by muck to the depth of one to two feet. There are several acres in this meadow tract.

14. JACOB VASS' FARM, LONG POND, three-eighths of a mile south southeast of Lincoln, and near the county line. There is no visible outlet to this little basin. It dries up in hot, summer weather. The muck covering is one to two feet thick. There may be three acres of marl here.

15. SINK POND. This marl basin is near the line of Warren county, and southeast of Lincoln, Green township, Sussex county. It has no outlet. In the summer it dries up. The area is between five and seven acres. At the top there is black muck and loam 1 to 2 feet thick. Blue, magnesian limestone rocks crop out on all sides.

16. HAZEN'S POND, Frelinghuysen township, Warren county. Marl is reported as occurring in and about the shore of this pond, but deep under the water and muck. There is no known outlet to the pond and the shores are very wet and swampy.

17. COOK POND, northeast of Johnsonsburg, Warren county. This marl deposit is in a narrow and long valley one mile north-

east of Johnsonsburg, Warren county. The length of this deposit is nearly one mile, while its breadth does not exceed an eighth of a mile. The marl occurs in the meadow and also in the pond at the head of the narrow valley. It is covered by black muck and lies upon the gravelly beds of drift. On the northwest blue limestone outcrops line the border of this meadow. The thickness of the deposit of marl is not known. As the meadow is wet and swampy in part, the extraction of the marl is not altogether easy.

18. GLOVER'S POND. This pond is one mile south of Johnsonsburg, in Frelinghuysen township, Warren county. It is in a blue limestone district. It covers an area of 50 acres. The marl is seen on the shores and under the shallow waters near the shores. Its thickness is not known. Much of it is not accessible, unless the water be allowed to run out, by deepening the outlet, or by draining it into Bear Creek on the northeast.

19. LONG POND, of L. J. Howell and A. M. Cooke, northeast of Hope, Frelinghuysen township, Warren county. This little pond basin is another of those having no visible outlet and becoming dry in the late summer. Its area is not over three acres. A spit of muck is found covering the marl. This deposit is thick, and is easily worked in dry weather.

20. GEO. H. BEATTY'S MEADOWS, west of Hope, Warren county. A large area of meadow land near the village of Hope, and is said to be underlaid by marl.

21. RICE POND OR REID POND MARL. This little pond is 2½ miles north of Hope. Slate Hills bound it on the northwest and blue limestone ledges on the southeast. Its area is 3 or 4 acres, with a narrow fringe of marsh. The depth of the marl was not learned.

22. GEO. CARTER'S FARM, south of Blairstown, Blairstown township, Warren county. Here marl occurs near the surface and is cut in ditching. There are several acres of meadow, but how much is underlaid by marl is not known. The drainage is northward into the Paulinskill.

23. WHITE POND. One mile north of Marksboro, in Hardwick township, Warren county, is the celebrated White Pond, so named from its shores of white marl. Its area is estimated at 100 acres. Its outlet is southward into the Paulinskill. The marl occurs more or less all around on the shores, and on the southeast is at

least 100 yards wide outside of the water line. Its extent in the pond is not known. It has been found 10 feet thick, but is probably much thicker in the pond. There is here a large body of marl which is dry and workable for most of the year. By lowering the outlet it might be possible to increase the extent of marl accessible at all times.

24. CATFISH POND, near Stillwater, Sussex county. Another pond without outlet, and drying up in summer. Its area is about five acres. The depth of the marl is unknown.

25. GRASS POND. This locality is in Green township, Sussex county, one mile south of Hunt's mills. The water dries up in the summer, hence the name of Grass Pond. Its area is said to be thirty to forty acres, and the marl is covered by black muck, excepting the central portion. Some digging has found a thickness of at least five feet.

26. ISAAC BONNELL'S FARM, Montague township, Sussex county. This marl is in a meadow along Chamber's mill brook. It covers an area of seventy-five to one hundred acres. Borings made years ago found it to be fifteen feet thick. It is covered by the soil and muck, about two feet thick. The surface marl is somewhat mixed with the muck. This locality has been worked, and the marl from it has done good.

27. ISAAC COLE'S FARM, southeast of Brick House, Montague township, Sussex county. The marl occurs in a meadow near the Milford and Hainesville road, and is said to have an area of fifty acres.

28. JAMES BEVANS' FARM, north of Hainesville, Sandiston township, Sussex county. Extent unknown. In a meadow.

29. FRANCIS LAYTON'S FARM, west of Centreville, Sandiston township, Sussex county. This deposit is in a basin between the limestone and the Cauda Galli grit rocks, and has an area of ten or twelve acres. It is now wet meadow, and the outlet brook from it flows southeast to Centreville. The ditches show a covering of black muck, one to two feet thick. Its thickness is estimated at ten feet in the deeper portions. The outlet could be lowered by slight cutting and the deposit be dried, so as to be accessible at all times of the year.

30. JAMES C. BEVANS' MEADOWS, near Dingman's ferry, Sussex county. This deposit has an area of seven to eight acres, and lies in a hollow between the Corniferous limestone and the

Cauda galli grit. The overlying muck is said to be one to two feet thick, and the marl may be three or four feet. At present this deposit is very wet meadow. The lowering of the outlet brook, which runs southeast to Peters' Valley, would drain it effectually, and make the marl easy to be got at all the year.

Shell marls have not found any considerable use or favor among the farmers in Sussex and Warren where they are most common. Some farmers use them and say that they are very beneficial to growing crops. Others have not been able to satisfy themselves that the marls are of much, if any, benefit. In foreign countries wherever an improved agriculture prevails they are highly esteemed, and are largely used. There can scarcely be a doubt that like results would follow their general and judicious use here.

Their readiest use would be on pastures; applied in the autumn, or when the marl is so dry as to spread very finely. A dressing of 5 to 15 loads an acre is safe, and is sufficient. It may be put upon wheat ground, and thoroughly worked up with the soil, where it will be found to increase the crop, and will also promote the after growth of clover. It is much to be hoped that farmers will give it a more careful trial before giving up that it is useless. There is so much of it, that if it could be successfully used it would be a great saving to the many farmers who need more manure on their farms, and who have an abundance of shell marl within convenient distances. It cannot but be valuable for it has in it the same constituents that are in leached wood ashes, principally carbonate of lime, and there is no land I think upon which the ashes are not useful. They sell readily at from 10 to 20 cents a bushels. The shell marl can be got for very much less than half that price.

There is an inquiry for such shell marls among those who propose to manufacture Portland cement. This cement is an artificial composition made by mixing together clay and fine limestone, burning and grinding them. It is much more highly valued by engineers than the common hydraulic cements, which are made from natural stone burned and ground. The uses of these cements are very large, and important. Attempts have heretofore been made to establish this manufacture in the neighborhood of New York, but they were unsuccessful. Other enter-

prises of the same kind are in contemplation, and must finally succeed. These marls are almost absolutely pure carbonate of lime; they need no grinding, being already nearly as fine as flour, and they are so near New York that they can be delivered there at the very lowest paying rates.

4. THE CONTINUATION OF THE UNITED STATES COAST SURVEY TRIANGULATION OF THE STATE.

This work which is the necessary basis of all our accurate Geographical and Topographical Maps has been continued through this year. The United States Coast Survey had many years ago located and measured a chain of primary triangles, across the middle of the State, and parallel to the sea coast, from New York to Pennsylvania. It had also extended a series of tertiary triangles along the country bordering on the waters of the Atlantic, the whole length of New Jersey, and up Delaware bay and river, above Trenton; and up Hudson river above the State line. Within a few years past, the law of the United States has allowed the officers of the Coast Survey to aid States which are conducting Geological or Topographical Surveys, by ascertaining for them the latitudes and longitudes of fixed points proper to be used for locating accurately on maps, the geography and topography of the country.

In accordance with this authority, the Coast Survey determined for us the latitudes and longitudes of the established ends of the boundary between New Jersey and New York, and computed the bearing of the straight line between them. In 1875 and 1876 the seasons were spent in selecting points suitable for another chain of primary triangles across the State. The country embracing the series of mountain ridges, which cross the State from northeast to southwest, in the counties of Bergen, Passaic, Sussex, Morris, Somerset, Hunterdon and Warren, was chosen in which to begin the work. The system of triangles at present begun, contains twelve primary stations, with sides varying from eleven to twenty-eight miles long. They are well shaped, and several of them join to form quadrilaterals. Two of these have been occupied the past season; one is now completed, and the other is nearly done. Two stations of the old series, Mt. Rose and Newtown, have also been occupied for determining the new

stations and connecting them to the former Coast Survey work. Observations have also been made upon twenty-three tertiary points from the stations occupied.

From the nature of this work it proceeds with extreme slowness, as compared with ordinary surveying, but it is the best method known for getting accurate work done; such as is found necessary in all thickly settled countries. The results are needed in our State now, and they cannot be got too soon, for our topographical work is going forward.

The stations occupied are Goat Hill and Pickels mountain, in Hunterdon county, and the tertiary points are nearly all in the same county.

5. TOPOGRAPHICAL SURVEY.

Topographical maps, showing the outlines and inequalities of the surface, are absolutely essential to the proper explanation and exhibition of our geological work. They also find important uses in plans for drainage, for water supply, for locating roads and railroads, for making studies for rural improvements, &c., &c.

The map of the Middlesex county clay district, which has on it lines indicating the elevations of the surface, as well as the location of the different clay beds, has found important and acceptable uses. It has been used to locate new openings for clay and found accurate, it has been used in court for ascertaining the prospective value of clay lands, it is referred to as authority on questions about artesian wells, and it has furnished clear and satisfactory information on questions of water supply.

The map prepared last year to show the basin and water shed of the upper Passaic and its various branches, has been much sought after, and the edition printed was exhausted long ago. By the color and figures marking elevations, it conveyed information not accessible to most people in any other way. The usefulness of this map for so many purposes of public interest, as well as for the direct question of water supply, for which it was made, has induced us to begin the preparation of a topographical map of the country between First mountain and the Hudson river. The projection is prepared on a scale of three inches to a mile, and the tertiary points, of which the latitude and longitude is known, have been determined by the United States Coast

Survey. The territory, embraced in the map which is in progress, is bounded on the north by an east and west line, drawn through the northerly curve of the Passaic north of Paterson; on the east by the Hudson, New York bay and Staten Island sound; on the south by Raritan river, and west by First mountain. This comprises an area of 408 square miles, and is the home of 456,-000 people, nearly half the population of the State, and is growing in population and wealth faster than any other part of the State. Much of the material for the location of roads and streams is already in existence. The main work required was in obtaining the heights of ridges, valleys, road crossings, &c., and in delineating correctly the outline of hills, slopes and other objects, which give variety to the surface.

The surveys have been in progress during a part of the summer, and the field work for the northern third of the map is done. The work is now going on, with the expectation that before the cold weather drives the surveyors from the field, all that portion from the northern end south, and including Newark and Orange, will be ready to put on the map.

6. DRAINAGE OF THE GREAT MEADOWS ON THE PEQUEST.

This work comes under the direction of the Board of Managers by the provisions of the law to provide for the drainage of lands. By this law the Board is authorized to prepare plans of drainage for tracts of wet land under specified conditions. The plans for the drainage of the Great Meadows were prepared by the Board in 1871, and commissioners to execute the plans were appointed by the Supreme Court in 1872. The work, however, was not fairly begun until 1874, and its progress has been somewhat delayed by difficulties incident to a large work of an unusual kind, and to the financial embarrassments of the times. It is now well advanced, and its good effects are already realized on the end of the tract nearest the outlet. All the obstructions in the Pequest from Larason's bridge, at the lower end of the meadows, down to Danville bridge, have been taken out. The reefs of tough clay and stones have been cut down so as to drop the bed of the stream five and a half feet at the former bridge, and to bring the channel to a uniform grade of descent of one foot per mile and to a full width of thirty feet. The water flows

through it with a strong and steady current of more than a hundred feet per minute, and all our recent freshets have not been sufficient to make the stream overflow its banks.

The channel of the Pequest in the meadows has been dredged out to the same grade and the same width as the outlet, from Larason's bridge up stream two miles and twenty-five chains. The channel of Hoagland's Mill brook is deepened and cleared in good condition from its junction with the Pequest, near Larason's bridge, up to Roe's island road, one mile and a quarter. The work of opening and clearing the channel of Schmuck's Mill brook has been carried along from its mouth at the Pequest river thirty-five chains, and is now in progress. The work of clearing the channel of Stinson's Mill brook has just been let out to a contractor. The outlet to Cummins's meadow ditch and the brook crossing the road to Post's island, is ready to be let out to contractors. These streams are all that cross the meadows and empty into the Pequest between Larason's bridge and the mouth of Bear creek.

The plan of drainage in the hands of the Commissioners requires for its completion the clearing of the channel of the Pequest to Long Bridge, and the bringing it to a uniform grade of descent. And the channel of Bear creek will need some clearing also.

The dredge will be taken out of the Pequest now, and all minor obstructions removed, so that the stream may have free flow, and the force of the current exert its scouring action upon the bottom and sides of the channel during the winter and spring freshets. It will be a matter of much interest to know whether the force of the water with the increased current will cut away the bottom of the channel, in that part of the stream immediately above where the dredging has just been stopped.

It was calculated that with a fall of one foot per mile, the current of the Pequest would be a foot and a half per second. By trials now, when the stream is little swollen, it is found to be over 150 feet a minute—several tests made showing 100 feet in 30, 33, 35, 37, 40 and 43 seconds respectively. This is much above what was calculated for.

The fall in Hoagland's mill brook is 8 feet per mile, and the current in it is rapid and proves to be ample for quickly carrying off all the water in times of heavy rain.

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The fall in Schmuck's mill brook as improved is 10 feet for the lower mile next Pequest river, and 7 feet per mile for the second and upper mile.

The Stinsons' mill brook has a fall of 12 feet per mile.

The meadow ditch and brook on the southeast side of Post's Island will have a fall but little less than that from Schmuck's mill, *i. e.* 6 or 7 feet per mile. These are all obtained by the present improvement which lowers the Pequest five feet or more under its former surface level, and so enables these branches to discharge their water at the low or improved level.

For clearing out the Pequest up to Long Bridge, the Commissioners propose to have the dredging begin at the upper end and work down, so as to have the deepened channel in which to float the dredge. This would save the necessity for dams in the channel, which are needed when the dredge works up the stream, as in the latter case it drains the water away from itself.

The work is going on to completion, and as far as there has been opportunity to see its effects, it is a complete success. The streams from the mountains on both sides, which were formerly almost lost in the spongy earth of the meadows, are now being opened out to the Pequest, and as far as they have proceeded they carry the water without any overflow. The meadows, which were formerly overflowed for a large part of the year, are dry.

The Commissioners of the Pequest drainage, are Amos Hoagland, of Townsbury; James Boyd, of Vienna; and William L. Johnson, of Hackettstown; and their engineer is A. R. Day, of Hackettstown. They are making every effort to carry the work through to a successful completion. For their enthusiastic interest in their work, as well as for the patience and perseverance they show, in meeting and overcoming its difficulties as they arise, they merit the highest praise.

Improvements of this kind are so uncommon in our country, that their value to agriculture, their sanitary benefits, and their influence on the reputation and attractiveness of all the surrounding country are not appreciated or even understood. Distrust, discouragement, and even active opposition are shown to them by the very persons to whom, with good management, they will become a mine of wealth. And they scarcely receive from the public authorities that encouragement to which, as great economic and sanitary benefits, they are so richly entitled. This

comes, of course, from not having any visible exhibition of the effects of such drainage, and will all be corrected as the results of experience are known and seen. It is demonstrated by the results in the present case, that the cleared Pequest does carry off the water with the rapidity calculated for at the planning of the work, and that there is no accumulation of flood water in the meadows, as far up as the clearing extends. It is also demonstrated that the small streams which formerly discharged their flood waters upon the meadows and submerged them, do now, as they are cleared, carry the water in their channels without overflow, and empty it into the Pequest. And it is demonstrated this year, by the work of farmers on the lands drained, that where they were cleared before, good crops can be safely and profitably cultivated the first year; and that where the ground has never been cleared, it can now be worked on steadily without any loss of time or threat of injury from standing water or sudden floods.

For particulars in regard to the Great Meadows and its former and present condition, reference may be made to the statements farther on in this report; and for other examples of drained lands and their value, reference is made to the meadows at Oxford Furnace, or to the banked meadows of Salem and Cumberland counties, in New Jersey, any of which can be shown to be easier cultivated, to cost less for manures, and to yield larger profitable returns, than the best of our uplands. In foreign countries the polders of Holland and the fen-lands of England, all of which are lands reclaimed from the water, are universally regarded as the model lands for agricultural productiveness and clear profit.

The subject is one of so much present and future importance that it is thought best to give some particulars in regard to agricultural and sanitary drainage in foreign countries and in our own.

Drainage has been practiced longest and most extensively in Holland, and what is demonstrated by the Dutchmen there is well stated in Mr. Waring's book entitled a "Farmer's Vacation," written from notes made there in 1873. Of the difference between the undrained German province of East Friesland and the drained Dutch province of Groningen, as he passed from one country into the other, he says: "Instantly the aspect of the country

changed, and we recognized the presence of the transforming hand of the Dutch Wizard of Drainage.

"In East Friesland the ditches had been nearly full to the brink, vegetation showed the ill effect of a wet soil, and there was a general air of swamp and fog over the land and its people. Here, the water was three or four feet below the surface, the land was dry, the growth was magnificent, and, though the country was flat as the sea, there was no suspicion of wetness anywhere. The few people we met were hardy and red-cheeked. The farm houses and barns grew larger and hay and grain ricks multiplied. Perhaps nowhere else in the world is such a sudden change of condition, due entirely to art, to be seen in a country of precisely the same original character."

He also says: "Although Holland took its first impetus from commerce, this has sadly fallen away, and now agriculture has on all sides filled and overflowed the gap. The reclaiming of the overflowed lands and ancient harbors has given them another and firmer hold upon prosperity, a prosperity, too, which is much more general in its influence, reaching all classes of the community to a degree unknown during the old commercial days. * * * The Netherlands have gone silently and quietly forward, until they have become one of the most advanced agricultural nations of Europe, exporting more of the products of the soil than any other, * * * and their wealth accumulates to a much greater degree than with any other agricultural people."

So profitable has ditching and draining of wet grounds and lakes been found, that they are just now beginning to bank in a lake of 480,000 acres, so that they may pump out the water which is eleven feet deep, and make the bottom into farms.

But it is not necessary to go out of our own State, or even out of Warren county and the valley of the Pequest, to show that drainage of this kind is an achieved benefit. At Oxford Furnace, in the valley of the Pequest, there is a large tract of land, formerly marsh or swamp and liable to overflow, which has been drained and reclaimed, and is now in profitable cultivation. An account of this improvement and its results, prepared for this report by Mr. Charles Scranton, of Oxford, is here given. He says:

"I will briefly answer the most important of the questions

asked relative to the operations of draining the meadows at Oxford, among which are the following:

"1st. Where and how large was the tract reclaimed?

"2d. What was its condition when the work was begun?

"3d. What streams, main ditches and side ditches have been opened or deepened to effect the drainage?

"4th. What is the present condition of the tract? What crops are raised on it, and are they as good as on upland?

"5th. Does it cost as much for manuring and tillage as an equal area of upland?

"6th. Can you estimate approximately the cost of reclaiming this land?

"7th. Has the drainage had any effect on the salubrity of the tract? Are fogs any less common than before the drainage was done?

"This tract of land comprises about four hundred and twenty acres of land, subject to overflow at every heavy rainfall, and is located in the eastern part of Oxford township, Warren county, and has on its edges or surroundings somewhat over a hundred acres more of sour land. It was in 1857 bog meadows and low swamp timber land, the timber being chiefly soft maple and birch. The Furnace brook passing through it on its winding course to the Pequest river, with the large number of rivulets and springs, kept the whole tract soft, spongy or wet, for the greater portion of the year, so that the timber could not be cut and brought to the shore, and the pasture was of very little value except for a few weeks in the dryest part of the summer. A small portion of the parts lying near the uplands, was generally mown for hay, of which it yielded a poor quality.

"In the year 1858, I dug a canal, following straight courses eighteen feet wide, and six feet deep, for the distance of about one and three-fourths of a mile, with four main ditches, generally about five feet wide at the top, one and a half feet wide at the bottom, and from four to five feet deep. The upper three-fourths of a mile has a fall of about nine feet, and the lower mile has a fall of about six feet. The canal has been self-enlarged by the freshets since occurring, so that it is now about twenty feet wide at the top, and seven feet deep, and carries all the water of an ordinary freshet. The timber has been cut off, the stumps have been pulled out and burned, and the bogs were cut off, piled in

heaps, and burned, the ashes, in each case, spread over the land, and about one-third of the whole tract has been limed.

"The crops raised are principally corn and hay. Very little manure has been applied to any portion of the tract, as so far it has not seemed to require it. Corn has been planted on the same ground for three and four years in succession, when it would become too weedy, and would then be sown with timothy seed, to mow for hay for three or four years, always affording a fine fall pasture. The present condition of the tract is incomparably better than it was ten years since, and the crops, corn and hay, and the pasturage, superior to any upland that I know of in this State. The hay crop is best where the largest alluvial deposit has been left by the overflowing of the meadows, while very little difference is observed on the corn crops. Sixty acres were planted with corn the present year, and from one acre, covering a part of each kind of soil, was the following yield in ears, viz.:

"184 bushels sound corn.

"8 bushels soft corn.

"Total 192 bushels, or an equivalent of about 104 bushels of shelled corn per acre, 56 pounds to the bushel. The acre was at the suggestion of Mr. Hendershot, (who farms for Mr. S. T. Scranton), carefully measured by Messrs. Wm. H. Scranton and Warren Ward, and contained 4,096 hills of corn, averaging 3.28 feet apart in each direction.

"After this kind of land has been once thoroughly got under cultivation, I think it safe to say that an acre of it is more easily plowed or farmed than an acre of ordinary upland. I will omit the cost, or approximate cost of reclaiming this land further than to say, that the original cost of the canal and main ditches referred to was about five thousand dollars, or say, twelve dollars per acre.

"I do not notice any particular visible effect on the salubrity of the tract by reason of the drainage. The families living near have been unusually healthy the past few years, while those living at an altitude of from one to two hundred feet higher have suffered from fevers, diptheria, etc. I might have remarked that the families living near the outlet some twenty years ago were subject to fever and ague, but it has scarcely been known

in that vicinity since the stagnant water has been carried off by the canal.

"The wheat and oats raised on this tract has only been in small areas. The soil being black and rich, would produce a straw too rank and weak to well support itself. This will be probably overcome in future years by the application of lime and manure, and so the soil may become less rich. Lime is not particularly needed for the crops of corn and hay, though I have no doubt but each of these crops would be benefited by the use of lime on these lands in a greater degree than are the same crops grown on uplands. In conclusion, I may say, that I believe the results shown in the drainage of these lands, practically demonstrate the value of drainage of similar and larger tracts of the same kinds of land in New Jersey, and that the time is not far distant when it will be seen that for certain kinds of crops such lands are vastly superior to any others in the State, for the reasons that they will produce more with less cost for manures, as they have, under proper management, a soil practically inexhaustible in fertility."

The following statement of the past and present condition of the Great Meadows has been prepared by A. R. Day, C. E., of Warren county, who has known about them all his life, and is thoroughly conversant with the progress of the present improvement from its beginning up to this time.

"I have given all the attention in my power, so as to answer your inquiries respecting the Great Meadows, which I do *seriatim*.

"1st. 'In regard to the early condition of the Great Meadows'.

"Since my earliest recollection this territory has been known as one vast swamp, much of it inaccessible to man or beast on account of water and sink holes, and in which numbers of cattle were annually lost by miring, in the earlier season and immediately after rains. There were some shallow ponds, or reservoirs of water, scattered over it; one of some size, known as the Goose pond, and as a water fowl resort and hatching ground during the summer. There being no outlet sufficiently low to carry off the spring or storm freshets, the whole territory of six thousand acres remained thoroughly permeated with water, thrown over it from the narrow and shallow channel of the Pequest river, through the whole length of the meadows, and the larger tributaries from the Johnsonburg mill stream, and the Hunt's mill

branch or Bear creek, from the Allamuchy mill stream, the Smoke's mill brook, the Stinson saw mill brook and the stream known as the Hoagland mill brook. These tributaries being all mountain streams in their source, rapidly threw upon the meadows after every rain-fall a large quantity of water, to remain in diffusion or overflow summer and winter; thus producing a most detrimental effect upon the health of the region, through which prevailed chills and fevers when prevalent nowhere else, thus leaving no doubt as to the *local* cause. No agricultural operations whatever were possible, even mowing small lots of grass upon the edges of the meadows being in some seasons interfered with.

2d. " 'The injurious effects of dams and fish weirs.'

"The want of a natural outlet for the Pequest, at the lower end of the meadows, was greatly aggravated by the erection of a three foot dam, one mile below the meadows and above Vienna, and the evils of this were increased greatly by several fish dams above the mill dam mentioned, all which retarded the current, choked up the stream, and constituted reservoirs for floating stumps, logs, brush and sedimentary deposits from the swamp above. But all these were only minor aggravations of the main and great evil—the want of a natural outlet and channel at the lower end of the meadows.

3d. " 'The former attempts to drain these meadows.'

"Of these, all were but local and partial; most of them merely private efforts, contemplating no general benefits, and little or no concert of action. There are on the statute books two different special acts, authorizing the drainage of these meadows, under which nothing effective was done. The Rutherfurd family, who owned and still own large tracts of these meadows in the Allamuchy district above Long Bridge, made some early efforts for drainage. In the Bear creek and Pine Run district still more extensive efforts, leading to some legal measures and resulting lawsuits, to drain have been made, dating back some seventy or eighty years ago, which appears to have been an energetic and determined effort. The natural outlet of Pine run into Bear creek, to the north of the old Warbasse property, was discarded, and a *wholly new artificial* outlet, much of it through dry and hard land, was made, to a point of discharge about half a mile farther down Bear creek. This was done to increase the fall,

but it is still insufficient to effect the drainage, and the water still stands all summer in the swamps along Pine run, in what is now spoken of as the "Harris district." This must always be the case till Bear creek outlet and channel are both widened and deepened.

"About sixty years ago, two enterprising gentlemen (one of them from Princeton, N. J.,) by the name of Addis and Wadsworth, attempted the drainage of the east side of the meadows, and constructed for Smoke's mill brook what they called the 'Main ditch,' over two miles long, and discharging into Pequest, north of what is now known as Post's island. This, too, after a few years, was neglected, giving no results equivalent to the expense; neither current nor discharge being possible, so as to relieve the great body of water to be provided for, which only can be secured by lowering and widening the channel of the Pequest.

"The late Christian Cummins, Esq., one of the most energetic and resolute of the property owners along the Great Meadows for half a century, also engaged in quite expensive operations for drainage, and made a ditch through his extensive property, long enough and large enough to be a reservoir of itself to hold the water ordinarily. But it was too level, no flow or outlet, and at this day is but a monument of the uselessness of attempted drainage *without* an outlet.

"The district fronting the Presbyterian Church at Danville, being the lower end of the Great Meadows, and often covered with water up to a stone's throw of the church steps, presented so hopeless a case that but little was ever attempted except a few short shore drains.

"The district on the northwest side of the Meadows, above and below Stinson's sawmill, is quite often covered with water except during the latter part of summer. But here are several old extensive ditches, which do not seem to have effected much, for the bogs are as large as a barrel, and sour, wet land, still close right on to the rocky hard-pan soil which skirts this shore of the Great Meadows. Considerable of this portion of the meadows is now held by the Crane Iron Company, the Scranton iron interests, the Philadelphia Marble Quarry Association and others, who have purchased the farms adjoining for their mineral products. They

are utterly unmanageable for any agricultural purpose in their present situation.

"The most extensive, intelligent and persistent effort ever made for drainage of the Great Meadows was made about twenty years since by Dr. J. Marshall Paul of Belvidere. Like his predecessors, he at first confined his plans to local ditches, but following the results of experience, he at last recognized the fact that he had no outlet. He then, in co-operation with some other enterprising citizens, bought out the mill dam near Vienna and removed it, also some fish dams; took out from the channel of Pequest river large numbers of stumps, logs and drift wood, which had some effect, but the enterprise soon came to a stand still, for want of co-operation among the owners, want of faith in final results, without a lowering of the bed of Pequest river. Since then no efforts have been made, till the requisite number of land owners, in 1872, petitioned for the appointment of commissioners under the General Drainage Act, which led to the work now being done for the drainage of the Great Meadows. This enterprise has been the hope of the neighborhood for three generations past. Our best and most prominent citizens have always advocated it, not only those in the immediate neighborhood, but throughout the country. Among them all I name but one. Dr. George Green of Belvidere stood high in our county, as one of our most pure and public spirited citizens in his day, and as a man of sound judgment whose opinion, on almost any practical subject of the time, all were glad to obtain. In the Annual Geological Report of New Jersey for 1855 will be found (page 120) his letter saying that 'the drainage could be suggested or recommended on public grounds that would be incontrovertible. I should think that the State, county, township and the community in this vicinity would all be benefited by the bringing into profitable cultivation so large a tract of comparatively worthless land, and making it one of the most valuable and productive in the State.'

"The actual cost of all these efforts to drain the Great Meadows it would be hard to state. That many thousands of dollars have been spent, and then abandoned without result, there can be no question. Much has been learned since that day, and there are now available the teachings of science and experience, and less likelihood of failure in any well considered system of drainage.

Unless it is denied that there is any benefit in relieving land of its surplus water, there can be no question as to the benefits of this enterprise. That it is certainly drying the Great Meadows is a fact patent and apparent to all. And this brings me to your next inquiry.

4th. "'The benefits which have been accomplished by the present work.'

"Among the most immediate of these, is the relief from those annual inundations so sure to come formerly with every spring. Now, with the outlet to the Meadows at the steam mill bridge (formerly Larason's), lowered five and a half feet, and the channel widened to thirty feet and lowered and graded to one foot per mile, the flow of water is free and unobstructed, it commences with the first rainfall, and there is no accumulation.

"All along the Pequest, below the dredge operations, are tracts of land which were under water not only in the spring of 1875, but in the summer of that year had to be passed over in boats in August, and are now dry, hard, fit for the plow and cultivation of corn. Hundreds of acres are already thus improved as to dryness, and other hundreds are relieved from all surplus water, but not yet so far advanced. The character of the grass and pasturage is also changing for the better, and there are now sweet, rich grasses where formerly water, weeds and wild aquatic grasses prevailed. In one tract owned by Simon A. Cummins, Esq., our county collector, he has this season laid over a mile of drain tile, and says he expects to raise next season, a crop of corn sufficient to pay his whole assessment. In former years I have seen this tract all under water, by back-water from the Pequest.

"His brother, Andrew J. Cummins, who carried around the original petition for signers to drain the Great Meadows, has also this year raised a large crop of corn on land formerly subject to overflow. You may be personally acquainted with this tract as it lies immediately in front of the Vienna Hotel, and and has never been plowed before.

"Rev. Ephraim Simonton, a retired clergyman, has also this year raised corn very successfully on land never before broken, and unavailable till this improvement. But perhaps the most remarkable crop has been a timothy crop near Danville, on newly drained land, formerly not only wet but submerged, raised by William Vreeland. Some of his neighbors are now plowing

and grass-seeding lands where the plow never ran before. There are other instances but these are sufficient. The Goose Pond, around which the sportsmen formerly waded in their long-legged boots, can now be passed over in low shoes. It has completely run off dry and no water fowl have been there this summer.

"5th. As to the prices of land in the Great Meadows, it is difficult to give definite figures. Most of the land is held in connection with adjoining farms, and taxed in the gross in that connection. I can recall but a single actual sale separately, and that some years ago, which brought three dollars an acre for one hundred and eighty acres. I know of another tract offered at five dollars an acre and no purchaser. Some lots where wholly or partially in timber have brought ten, fifteen or twenty dollars an acre. Their inaccessibility except in winter very much depreciates their market value as we have many winters when they cannot be reached at all."

The Great Meadows have always been noted for the prevalence of malarial diseases in their vicinity. The former sanitary condition of the country around them is best shown from the testimony of the practitioners of medicine, who have attended the sick there. The gentlemen whose letters follow here are all practitioners who have had a wide experience and for a long period of time. In the country where they are known it would be needless to say that their statements and opinions are entitled to the fullest credence.

From Dr. John S. Cook, of Hackettstown:

"In my conversation with you at our last meeting I mentioned that the Pequest valley, during the last thirty years, had been visited by several epidemics, which assumed a malarial type, while our Musconetcong valley had been comparatively exempt from such visitations. We have malarial diseases, but they never assume an epidemic form. I have no data from which to give you definite information, and, therefore, can only write in a general way from my own knowledge.

"The valley of the Pequest comprises an area of country where malaria is endemic and where it prevails every year to a greater or less extent. The topography of the district is such as to favor its production. We have a plain situated between mountains, into which the heavy rains and inundations of cen-

turies have deposited great masses of vegetable matter, and this with the varying seasons of each succeeding year, has been permitted to decay until we have a soil composed of this vegetable mold of several feet in depth, and this being deposited upon a deeper floor of clay and other impenetrable soil, presents conditions the most favorable for its development, especially when we have a large amount of surface water loaded with vegetable ingredients percolating through the loose upper earth and held on the surface of the lower stratum. The drainage of this district must make it one of the most fertile in this portion of the State, and it must also affect most favorably the health of its inhabitants. This will be brought about not only from the removal of the surface water, but from the absorption of decomposing organic matter by the growing crops.

"I can recall an epidemic of dysentery which prevailed throughout the valley, and especially in the neighborhood of Vienna, during the fall of 1857. This assumed a decided malarial type and was fatal in many cases. Scarlet as well as typho-malarial fevers where they have prevailed, have assumed a malignant type. In the fall of 1874, an acute laringytis prevailed in the neighborhood of Schmuck's, which was of an unmanageable form and a number of deaths occurred, adults as well as children being among its victims. Dr. Wm. I. Roe who has been located at Vienna for a number of years says that disease at almost every stage of its progress has a tendency to assume a malarial type, and this tendency is no more than one might expect to meet with, when we take into consideration the sanitary conditions by which his patients are environed.

"I have given you in this general way, some information gathered in the course of my experience during several years of active practice in both valleys, and in conclusion, I have to say, that we meet with few, if any, such cases of malarial diseases in the Musconetcong valley, as are frequently to be found in the valley of the Pequest.

From Dr. Wm. I. Roe, of Vienna, Warren county:

"Yours inquiring in regard to malarial diseases of the Pequest valley in the vicinity of the Great Meadows is at hand.

"Nearly thirty years ago, I was in practice for two years at Danville on the lower border of the Great Meadows. At that time the prevailing diseases were, for the most part, malarial in

character. The intermittents were very severe, and many of the residents expected the usual attack of "chills," as surely as they looked for the coming of spring, while a family moving in the neighborhood from a non-malarial district seldom escaped the ravages of miasma in one form or another.

"In 1872, after an absence of twenty-five years, I again commenced practice in this vicinity. While I find a proportion of diseases of malarial type, they have not occurred to nearly the extent that they did during my previous residence here, nor have they been of so severe a form. During the past six years there has been a gradual diminution in the number of miasmatic cases, more particularly during the past two summers. I have attributed this to the drainage of the lower portion of the Great Meadows.

The malarial diseases which prevail here are the usual varieties, viz.: Intermittent and remittent fevers, neuralgia, typho-malarial and congestive fevers. The intermittent or common "chills and fever" is the most frequent. For two years past neuralgia of a severe and intractable form has been more prevalent than in former years. Remittent fever has not been frequent or severe. I have noted an occasional case of typho-malarial and two of congestive fever. The greatest number of cases have usually occurred during the summer months. The present year however is an exception, the greater number occurring during the months of September and October.

"These diseases seem to prevail to a greater extent along the southern border of the meadows than along either the eastern or western. It may be of interest in this connection to state that during the past six years there has been but one case (and that a very mild intermittent) on either of the three so-called islands, situated in the very center of the Great Meadows. More than sixty different persons have been residents of these islands during that period. Comparing the extent of malarial disorders in the Pequest valley, with those of the Musconetcong, I think that for two years past there have been a greater number of cases in the latter, particularly in that tract situated between Waterloo and Hackettstown, popularly known as 'Guinea Hollow.' I have seen quite a number of obstinate remittent and intermittent fevers in that vicinity, and have been informed that they prevailed very extensively, scarcely a family escaping. They

have been of a much graver nature and more intractable than the same affections occurring in the valley of the Pequest.

From Dr. N. M. Hartpence, of Oxford, Warren county:

"My practice has not been extensive in the country bordering on the Great Meadows, yet from the experience I have had I am convinced that malarial diseases are very prevalent there, and that you are correct in believing that such a body of land overflowed with water at times, is a fruitful source of such diseases, more particularly intermittent fever, and as observation has fully demonstrated that malaria is generated more especially in marshy situations, and that it affects by preference low and marshy localities, and in proportion as countries previously malarious are cleared up, periodical fevers disappear, I feel warranted in saying that a thorough drainage and cultivation of those lands, will finally be of great public benefit viewed even from a sanitary point."

From Dr. E. T. Blackwell, Hackettstown, N. J.:

"It was my fortune to pass the year 1849 at Townsbury, Warren county, two miles below the lower limit of the Great Meadows, but quite near enough to be strongly within the influence of its unwholesome emanations. The health of the community was good until the beginning of August; when malarial diseases, in great variety, and of all grades of intensity became extremely prevalent. Until winter this outbreak continued, prostrating in some instances three or four members of the same family. The year 1850 I passed at Danville, immediately on the edge of the Great Meadows. My experiences with the malaria were here repeated in an intensified form. During the preceding endemic, by shunning exposure in the night time, and when this was impossible, by wearing a handkerchief, arranged as a respirator, I was able to avoid its worst effects upon myself. Here all devices failed; and I experienced in my own person its poisonous results in an attack of fever.

"It appeared to me while sojourning in this neighborhood, and marking the effect of these blighting influences upon the health of the people, that I could perceive, in the lessened vigor and robustness of many of the residents, the results of this insidious and baleful poison. According to my observation, this is by far the most malarious district in this part of the State. The outbreak of malaria always occurs when the overflow of the

Pequest, drying up, leaves its sedimentary matter, as well as the earth saturated with deadly gases, to the full influence of the fierce autumn sun.

"No lover of his species can fail to hail with satisfaction every attempt by legislative means to improve the public health, by the prevention of all diseases, resulting from causes of a public nature; and I recognize in the drainage of the Great Meadows, an undertaking destined to exert a controlling influence in improving the healthfulness of this portion of our State."

7. MISCELLANEOUS LABORATORY WORK.

In addition to the regular work of the Laboratory in analyzing clays, ores, and soils which are the regular work of investigation in the Survey, some other work has been done. The miscellaneous inquiries in regard to natural products of the State have been answered as far as time would permit. There are a number still awaiting examination, which will be attended to as soon as the work in hand can be laid aside.

The following are among the substances examined:

Nickel Ore.—Two samples of rock containing pyrite, taken from a shaft sunk by William Davis, between Chester and Peapack, have been examined for nickel, but none was found. A sample taken from the southeast slope of Jenny Jump Mountain, and on land of A. Davis, was also examined for nickel, but none was detected. Numerous other specimens have been sent from different places in the northern part of the State, but none have been found which contained any nickel. The price of this metal has diminished so much, and the demand for it has fallen off so greatly, that it is probable less interest will be felt in searching for it.

Gold.—It is very generally reported that the iron pyrites which is found in the conglomerate of the Blue Mountain contains gold. A number of specimens from different places in the mountain have been examined at various times, but none of any value has ever been found. A sample brought by F. La Bar, from a few miles above the Water Gap, has been assayed this year, but no gold was found in it. One or two samples sent by other parties, and from different places along the mountain, are in the laboratory now. From the trials already made, it is safe

to say that there is no encouragement to work in the mountain with the expectation of finding gold, even if the iron pyrites is very abundant in it.

Iron Ore.—Bog iron ores are frequently brought in to be examined. Generally they are not rich enough to be used for making iron; besides that, those in the middle and southern part of the State have generally been found to contain so much phosphorus as to spoil the quality of the iron. A sample brought in by T. F. Carman, from Menlo Park, Middlesex county, contained only 12.15 per cent. of iron. A sample sent by Henry Bingler, of Hainesburgh, Warren county, contained 32 per cent. of iron.

Magnetic iron ore, sent by Mr. Cramer, from his mine east of Hackettstown, on Schooley's Mountain, Sample No. 1, a rich ore, contained of

Metallic iron	62.23
Titanic acid	9.80
Phosphorus	.14
Sulphur	none
Manganese	a trace

Sample No. 2, a lean ore, contained of

Metallic iron	40.25
Titanic acid	4.20
Phosphorus	.39
Sulphur	.?
Manganese	a trace

Analysis of iron ore from Fisher mine, on Fox Hill, sent by John D. Mills, of Rockaway, Morris county, for Mills, Willison & Co. The vein is said to be 10 or 12 feet thick, and the average sample was made from pieces taken entirely across the whole thickness.

ANALYSIS.

Magnetic oxide of iron	79.40
Phosphorus	.04
Sulphur	.59
Lime	2.70
Magnesia	.94

Manganese	0.00
Silica	11.90
Titanic acid	a trace
Metallic iron	57.50

This is a fine looking ore, and contains so small an amount of phosphorus that it ought to be available for making the very best kinds of iron.

A. J. SWAYZE'S HEMATITE.—This hematite locality is in Hope township, three and a half miles south of Blairstown, Warren county. The first work done on this farm was four or five years ago, by Ziba Osman, who, at that time, owned it. Ore was then found, but not in sufficient quantity to encourage the continuation of the work of exploring, or lead to mining.

In January, 1877, Mr. Swayze began the work of testing the property, by sinking a number of trial pits. The ground explored is northeast of Rice pond and southeast of the farm house. It slopes towards the west. The top of the ridge east of the pits shows slate outcrops; west of them, and west of the road, alluvial and diluvial beds conceal the strata. The pits dug by Mr. Swayze are between 20 and 50 feet deep, and 2½ feet wide. They showed, in general, a bed of unsorted boulder drift, of varying thickness, and consisting of blue, clayey earth and gravel, cobble stones and boulders of all sizes. Many of the latter are beautifully striated. In some of the pits this bed of drift was only a few feet thick. The maximum thickness, 28 feet, was found in a pit (unfinished at time of visit), near the foot of the hill. Under the drift the yellow, ochrey clay and ore is found. The hematite occurs in small fragments, and in "bomb"-like masses in the clay. In two of the trial pits, and in the working shaft, the *ore bed* rests upon a yellowish, earthy slate, apparently a slate which has been very much altered, and has become soft and crumbling. It is supposed that deeper pits would soon get through this soft rock, and reach the hard, unchanged blue slate of the hill.

The working shaft is southeast of the farm house, about an eighth of a mile, and half-way up the hill side and near the Osman openings. In it the strata are: drift earth, 8–9 feet; then the ore bed, 8 feet; and at the bottom, the yellow slate. From

this shaft a drift, 20 feet long, was cut, going eastward and ascending in the ore bearing clay. Another, 30 feet long, followed the same bed towards the west. These drifts indicated considerable variation in the thickness of the ore body. Most of the ore was *wash ore*. South southeast of the shaft, and higher up the hill side, a pit, 20 feet deep, struck the ore near the surface, and found it 2 to 4 feet thick. A pit south of the shaft was 50 feet deep, and the drift covering was 20 feet. In it there was 1 to 5 feet of ore in one body, with two lower *veins* or deposits. These test pits show somewhat of variation, but they indicate the existence of ore throughout an area of several acres, and in workable thickness.

About 100 tons have been raised at the main working shaft Mr. Swayze reports making some iron from it, using charcoal in a forge. It was soft and tough.

An average sample, obtained at the shaft, was analyzed in the State laboratory, and found to contain:

Matters insoluble in acid	12.40
Oxide of iron	67.92
Water	13.20
Oxide of manganese	1.10
Phosphoric acid	0.45

Or, of

Metallic iron	47.44
Phosphorus	0.19
Manganese	0.79
Sulphur	none

These results indicate a moderately rich ore, with comparatively little phosphorus, no sulphur and manganese enough to have a beneficial effect in smelting. It ought to answer for Bessemer steel making.

This locality is interesting as it shows the slate rock covered by the ore-bearing clay, and that in turn by the boulder drift.

Northeast of the farm house the blue limestone crops out, the end apparently of a belt or tract which extends thence southwest along Rice's pond and west of Hope. Near this point there is an outcrop, a few yards square, of micaceous gneiss in which pyrite is a common mineral. A little digging has been done

here in search of valuable ore. There appears to have been a great deal of erosion here which has worn down the limestone, making it the bottom of the valley and leaving the slate in ridges enclosing it. And originally this limestone may have extended eastward and joined the slate where the hematite now appears. The drift is a later formation which has covered both ores and rocks alike.

Franklinite iron ore.—Explorations made this year for franklinite and zinc ore, at the southwest end of the zinc vein in Stirling Hill, Sussex county, have exposed a large body of ore, of peculiar composition. It is in the ore vein, associated with the zinc minerals and calcite, and to the eye presents the appearance of massive franklinite. A specimen analysed in August was found to contain of:

Metallic iron	51.98 per cent.
Metallic manganese	7.40 per cent.
Metallic zinc	3.15 per cent.
Earths insoluble in hydrochloric acid	7.70 per cent.

Another sample taken from farther in the mine, in September, was analysed with the following result:

Metallic iron	51.21 per cent.
Metallic manganese	7.40 per cent.
Metallic zinc	6.24 per cent.
Silicic acid and insoluble earths	9.80 per cent.

This mine is opened by Messrs. Silsby and Martin, of Ogdensburgh, Sussex county. A tunnel has been driven in from the road near the foot of the hill so as to cut across the vein at a depth of more than 100 feet below its outcrop on the hill above. An enormous mass of this ore has been uncovered by this means, and it is mined at the smallest possible expense. The ore is met in the tunnel for over a hundred feet in length, but the vein is so much broken that it offers no safe basis upon which to calculate the amount of ore the mine will yield. There are thousands of tons of it, in sight, as the vein is opened to the top, so that the ore can be seen all the way from the tunnel upwards.

It is a valuable ore for working into Bessemer metal; and has found a ready sale to the iron manufacturers.

Limestones.—Five samples of limestone, collected by M. G. Smith, from his land, near Polkville, Warren county, were examined to determine whether they were *pure* or *magnesian* limestones, and the amount of earthy impurity in them.

No. 1 is a magnesian limestone, and contains 10.9 per cent. of earthy impurities.
No. 2 is a magnesian limestone, and contains 9.2 per cent. of impurities.
No. 3 is a pure limestone, and contains only 6.1 per cent. of impurities.
No. 4 is a magnesian limestone, and contains 20.7 per cent. of impurities.
No. 5 is a magnesian limestone, and contains 21.6 per cent. of impurities.

Lime made from No. 3 would be worth fully fifty per cent. more per bushel, in the stone, than that made from either of the others. If the magnesian limestones must be used, Nos. 1 and 2 are the best. The magnesia is about two-fifths of the weight of the magnesian lime, and as it is commonly burned now with coal, it probably has no value as a fertilizer. Formerly, when burned with wood, with which the heat is not so intense, the magnesian lime was best liked for making mortar, because it set quicker than pure lime; but when burned with coal it is not as good as the pure lime, even for that use.

Henry Bingler sent seven samples of limestone from his farm on the north side of the Paulinskill near Hainsburgh, Warren county. They were examined in the same way as those just mentioned.

No.	Earthy impurities.
1. Limestone	15.5 per cent.
2. Magnesian limestone	6.9 per cent.
3. Magnesian limestone	5.1 per cent.
4. Limestone	18.1 per cent.
5. Limestone	2.5 per cent.
6. Part limestone and the rest magnesian limestone	11.8 per cent.
6. Limestone with some magnesia	13.4 per cent.

Of these specimens number five is the best of the limestone, but all the limestones are more valuable for farmers use than the magnesian limestones. The latter are very good of their kind.

It would be much to the advantage of farmers if they would take pains to get pure limestones from which to burn lime for agricultural use. There are good localities for it near Manunkachunk on the Delaware; also, near Johnsonsburg, on the road to

Hope; on the same road near Howard; also on the same road a half mile northeast of Hope, all in Warren county. Near Stillwater, in Sussex county; near Fredon, west of Newton; at Newton; and, in fact, it can be found almost everywhere between the blue limestone and the slate, and it can be distinguished by its dark or almost black color, its fine grain, its somewhat slaty structure, and some of it contains fossils. It may be mistaken for slate, but an experiment by burning and slaking will show the difference. Or by testing with strong vinegar, when the limestone will effervesce, while slate will not.

Mineral Water.—J. W. Sutterly, in digging his well at Point Pleasant, obtained water charged with mineral substances, and brought it for examination. It contained 7.85 grains of solid matter in one gallon of the water, of which 4.14 grains are carbonates of iron, magnesia and lime, 3.65 grains of chlorides of sodium and potassium, and a little sulphate of potash. It is a pleasant chalybeate water.

8. CENTENNIAL MAP OF NEW JERSEY.

This map has been prepared by the survey first for the Centennial Commissioners' report, but it is the property of the survey and will be useful for many purposes of our work. It is believed that it has on it all the townships of the State, and all the canals and railroads, and nearly all the country roads. It is on a scale of 6 miles to an inch. In the centennial report it is accompanied by a copy of a map of New Jersey on nearly the same scale, which was made by British officers before the revolution, and engraved and printed in London in 1777. The two show something of the changes which have been made in the civil geography of New Jersey in one hundred years.

9. MUSEUM OF THE GEOLOGICAL SURVEY.

This museum occupies all the front of the third story of the State House. It is open every week day. The specimens of the Geological Exhibit at the Centennial, and most of those of the Agricultural Exhibit, are arranged here. It is visited by our own citizens from all parts of the State, and by strangers who come to see the State House, and its various departments and

offices. In this way our various mineral and other natural products are brought to the notice of large numbers of people. It is desirable to add to the collection any specimens from the State which will improve it, in variety or quality, and donations for this purpose will be gladly received and placed on exhibition with the name of the donor.

Contents.

GEOLOGICAL SURVEY OF NEW JERSEY.

ANNUAL REPORT

OF THE

STATE GEOLOGIST,

FOR THE YEAR

1878.

TRENTON, N. J.:
NAAR, DAY & NAAR, PRINTERS.
1878.

c

Board of Managers.

His Excellency, George B. McClellan, Governor, and *ex-officio* President of the Board.....Trenton.

I. CONGRESSIONAL DISTRICT.

Charles E. Elmer, Esq.....Bridgeton.
Hon. Andrew K. Hay.....Winslow.

II. CONGRESSIONAL DISTRICT.

Hon. William Parry.....Cinnaminson.
Hon. H. S. Little.....Trenton.

III. CONGRESSIONAL DISTRICT.

Henry Aitkin, Esq.....Elizabeth.
John Vought, M. D.....Freehold.

IV. CONGRESSIONAL DISTRICT.

Selden T. Scranton, Esq.....Oxford.
Thomas Lawrence, Esq.....Hamburg.

V. CONGRESSIONAL DISTRICT.

Hon. Augustus W. Cutler.....Morristown.
Col. Benjamin Aycrigg.....Passaic.

VI. CONGRESSIONAL DISTRICT.

William M. Force, Esq.....Newark.
Thomas T. Kinney, Esq.....Newark.

VII. CONGRESSIONAL DISTRICT.

Benjamin G. Clark, Esq.....Jersey City.
William W. Shippen, Esq.....Hoboken.

GEOLOGISTS.

George H. Cook, State Geologist.....New Brunswick.
John C. Smock, Assistant Geologist.....New Brunswick.

To His Excellency George B. McClellan, Governor of the State of New Jersey, and ex officio President of the Board of Managers of the State Geological Survey:

SIR—I have the honor herewith to submit my annual report on the progress of the State Geological Survey for the year 1878, as required by the "Act to complete the Geological Survey of the State, approved March 30th, 1864."

With high respect,

Your obedient servant,

GEORGE H. COOK,

State Geologist.

REPORT.

INTRODUCTION.

The Geological Survey of the State has for its objects—

1. To trace out and describe the various rocky and earthy strata and deposits which occur in the Geological Formations of New Jersey, and the soils which cover its surface;

2. Search out and describe the ores, marls, clays, limestones, waters and other useful natural products in it;

3. And to accompany the descriptions with such suggestions, recommendations and publications as may help to make them useful to the State.

The plans of the survey are made to carry out these important objects, and work has been done in all of them during the past year.

The results of the work done are arranged under the following heads:

1. The glacial and modified drift.
2. Preliminary classification and description of the soils of New Jersey.
3. Miscellaneous clay deposits.
4. Glass sand.
5. The United States Coast Survey, Triangulation and its progress in the State.
6. Topographical survey of the country between the Watchung mountains* and the Hudson.
7. Progress of the drainage works.
8. Water supply.
9. Laboratory work.
10. Statistics.
11. Publications of the survey.
12. Expenses.
13. Persons employed.

*The name Watchung occurs in the description of the tract of land purchased by the original settlers of Newark. The deed is dated July 11, 1667, and is there spoken of (East Jersey Records, Book 68,) as "the great mountain called Watchung." This is probably the oldest known name for the mountain, and in this survey and description it is proposed to use the name for this well marked range of trap-rock ridges.

1. ON THE GLACIAL AND MODIFIED DRIFT.

In the last annual report the fact was pointed out that the glacial or boulder drift was limited to the northern part of the State, and covered less than one quarter of its surface; and its southern border was traced across the State and described in general terms. This remarkable and interesting feature of the country has undoubtedly been produced by the action of a great glacier, which has covered the whole northern part of our country in recent geological times. The deposits it has left, and the influence it has had on the surface, soils and drainage of the country, make it desirable to present the description more in detail.

The glacial markings and drift are found at the top of the highest parts of the Blue Mountain, from the Water Gap on towards the northeast quite to the State line. And all the lower grounds are marked in the same way, except that near the frontal or southern edge of the deposit, the markings on the high grounds do not extend as far south as they do on the lower.

The directions of some of these markings, as observed in various places, are given in the following table:

TABLE OF GLACIAL MARKINGS.

MAGNETIC BEARINGS.

I. Western Slope of the Kittatinny, or Blue Mountain and Delaware Valley.

	Location.	Rock.	Direction.
1	Greenville road, one-half mile east of Carpenter's Point, Orange county, N. Y....	Oneida conglomerate.	S. 35° W.
2	Greenville road, summit of mountain, Orange county, N. Y.........................	Oneida conglomerate.	S. 60° E.
3	Port Jervis and Coleville turnpike, one mile west of summit, Sussex county.....	Oneida conglomerate.	S. 45° E.
4	High Point (summit)...........................	Oneida conglomerate.	S. 75°-80° W.
5	Ledges near Hornbeck's mill, Montague, Sussex county................................	Cauda galli grit.	S. 80°-85° E.

I. Western Slope of the Kittatinny—(Continued.)

	Location.	Rock.	Direction.
6	Peters Valley and Newton road, one-quarter mile west of road to Walpack, Sussex county	Medina sandstone.	S. 45° W.
7	Newton and Flatbrookville road, western slope of mountain, Sussex county	Medina sandstone.	S. 16° W.
8	Newton and Millbrook road, top of mountain, Warren county	Oneida conglomerate.	S. 16° W.
9	Newton and Millbrook road, down mountain slope, Warren county	Medina sandstone.	S. 40° W.
10	Mountain, two miles northeast of Water Gap (on crest of western ridge), Warren county	Oneida conglomerate.	S. 30° W.
11	Mount Tammany, Water Gap, Warren county	Oneida conglomerate.	South.
12	Dunfield Hollow, Water Gap, Warren county	Medina sandstone.	S. 10°-15° W.

II. Southeastern slope of Kittatinny, or Blue Mountain.

1	Port Jervis turnpike, one mile north of Coleville, Sussex county	Slate.	S. 30° W.
2	Southwest of Long Pond and near the Newton and Walpack road, Sussex county	Slate.	S. 80° E.

III. Kittatinny Valley.

1	Hamburgh road, Mine Hill, Sussex county	Zinc ore.	S. 30° W.
2	Fredon road, Newton, Sussex county	Zinc ore.	S. 35°-40° W.
3	Newton and Millbrook road, one mile west of Stillwater, Sussex county	Zinc ore.	S. 35° W.
4	Ledges east of Nelson Cummins' and near Great Meadows, Warren county	Gneiss.	S. 20° W.

IV. Highlands (and included valleys).

1	Passaic Zinc Company's mine, Sterling Hill, Sussex county	White limestone.	S. 15° W.
2	Sparta Mountain, one-half mile northwest of Woodport, Sussex county	Gneiss.	S. 5° W.
3	On Green Pond road, west of Lyonsville, Morris county	Gneiss.	South.
4	Copperas Mountain, east of Green Pond, Morris county	Conglomerate.	S. 10° W.
5	Green Pond Mountain (western) slope, west of Green Pond, Morris county	Conglomerate.	S. 30° W.

V. *Watchung (First, Second and Hook) Mountains.*

	Location.	Rock.	Direction.
1	Gap, west of High Mountain, Second Mountain range, north of Paterson, Passaic county	Trap rock.	S. 30°–40° W.
2	Second Mountain, west of Paterson, Passaic county	Trap rock.	S. 80° W.
3	Pompton Furnace, near knife factory, Passaic county	Trap rock.	S. 15°–20° W.
4	Paterson, on Little Falls road, Passaic county	Trap rock.	S. 75° W.
5	Second Mountain, summit, on Mount Pleasant turnpike, Essex county	Trap rock.	S. 48° W.
6	First Mountain, summit, near Eagle Rock, Essex county	Trap rock.	S. 58°–60° W.
7	First Mountain, near foot, Centreville road, Essex county	Trap rock.	S. 72° W.
8	Hook Mountain, northwest slope, on Beavertown road, Morris county	Trap rock.	S. 25° W.
9	Hook Mountain, north slope, and near peat works, Morris county	Trap rock.	S. 60° W.

VI. *Valley between Watchung First Mountain and Palisades Mountains.*

1	Paramus, near Reformed Church, Bergen county	Red sandstone.	S. 30° W.
2	Newark, Hoehnle's brownstone quarry	Red sandstone.	S. 25°–30° W.
3	Snake Hill, near almshouse, Hudson county	Trap rock.	S. 20°–30° W.
4	Sparkill, Bergen county	Trap rock.	S. 15°–20° E.
5	Homestead station, foot of mountain, Bergen county	Trap rock.	S. 10° W.
6	Salterville, ledges on shore of Newark bay, Hudson county	Trap rock.	S. 10°–20° W.

VII. *Palisades Mountain Range.*

1	High Torn, Haverstraw, N. Y	Trap rock.	S. 10° W.
2	Boulevard north of Alpine, on top of mountain, Bergen county	Trap rock.	S. 30°–45° E.
3	Palisades Mountain House, east of Englewood, top of mountain, Bergen county	Trap rock.	S. 35°–40° E.
4	Fort Lee, Bergen county	Trap rock.	S. 20°–25° E.
5	Hudson City, ledges in new reservoir, Hudson county	Trap rock.	S. 20° E.
6	West end of D., L. and W. Railroad tunnel, Bergen Hill, Hudson county	Trap rock.	S. 10° E.
7	Montgomery avenue, Jersey City, Hudson county	Trap rock.	S. 42°–45° E.
8	Newark and New York Railroad, east end of cut, Bergen Hill, Hudson county	Trap rock.	S. 35°–37° E.
9	Newark and New York Railroad, west end of cut, Bergen Hill, Hudson county	Trap rock.	S. 20° E.

The masses of sand, clay, gravel, loam, cobblestones and boulders which characterize this formation, are not distributed evenly over the surface. In some places they appear as rounded hillocks, in others as long ridges, in some instances straight, and in others curved—some as level topped hills or terraces—and others as uniform plains.

The materials are in two very different states of arrangement. In one part, and that usually the upper, the stones, sand and clay are all mixed together, and the stones which are in many instances angular, stand on edge, on end or in any way, as if the whole mass had been dumped pell mell, while in the other part, and that usually the lower, the materials are somewhat sorted and have a partial and limited stratification. This stratification is sometimes very oblique and quite wedgeform, and not in extended parallel layers. These two states of materials correspond very nearly with what are seen at every glacier at the present time and are known, the first as the superficial moraines, and the second as the bottom moraines.. The one is formed by the stones, sand, clay and rock fragments which are torn or fall from the sides of the valleys upon the surface of the glacier, and are carried forward by its movement and finally deposited in piles at its end, or upon the bottom when the glacier melts away. The other is formed of the sand, stones and mud, which are ground between the solid rock of the valley and the under side of the glacial ice as it moves along. The latter material may become partially stratified by the action of the streams of water which come from the melting glacier, and find their way down between the ice and the rock. Examples of this characteristic feature of the drift are well seen in the various cuttings and railway approaches to the tunnels in Bergen Hill on the west side.

The materials of which the drift is composed, are collected from all the rocks over which the glacier has moved in its passage from the north towards the south. From the friction and wear to which they have been exposed it will readily appear that the fragments of the softer rocks will soon be worn to mud, that the hardest will last the longest, and of course may be carried the furthest, and such is the case. The boulders and specimens of stone large enough to be identified with the solid rock from which they came, are found five, ten, twenty, thirty,

and possibly many more miles south of the parent rock, and in the same pile it is not uncommon to pick out specimens of granite, gneiss, hornblende rock, trap-rock, conglomerate, sandstone, slate, limestone, chert, quartz, feldspar, silicified fossils, &c., all of which are identical with rocks found to the north of them.

They differ from the stones found in a stream of running water, which are all worn and round, inasmuch as some of these are quite angular, having been carried on the glacier without friction, and others are marked with straight scratches, generally running lengthwise of the stone, as if the stones had been held firmly and pushed forward over sand and gravel stones to produce these marks. These scratches are best preserved on stones of limestone or hard slate, and are indistinct on granitic stones or on sandstone.

The mass of material varies much in its consistency, being more sandy when the rock from which it was worn was mainly sandstone or quartzose, and more clayey if the original rock was feldspathic, or slaty or trappean, and different mixtures of these give earths and soils of the most varied degrees of toughness, composition and agricultural quality.

A short account of the phenomena attending glaciers, at the present time, may enable the reader to better understand and appreciate these relics of the old glaciers which formerly covered all the northern part of New Jersey.

Glaciers are immense masses of ice which remain throughout the year, neither melting nor materially diminishing in the heat of summer, though they extend down to a level from 3,000 to 4,000 feet below the line of perpetual snow. The best known glaciers at the present time are in Switzerland, where they occupy many of the upper valleys in the Alps. The Norwegian glaciers are also well-known. There are a few small glaciers on Mount Shasta in California, and some on the highest mountains of Oregon; but they are inconspicuous and have been seen by few geologists. Greenland is almost entirely covered with glaciers, more than 300,000 square miles being covered by ice and snow. Careful observations have proved that glaciers retain their permanent places not because they are not melted by the summer's sun, but because the ice of which they are composed is slowly moving down the valleys in which they exist, and continue to do so until at their lower ends they melt away as fast

as they move. When this point is reached they *appear* to remain stationary. The movement of the Alpine glaciers averages 8 or 10 inches per day, while one of the great Greenland glaciers has been seen to move more than 40 feet in a day. The motion is more rapid in summer than in winter, and the advance of Alpine glaciers is so slow as not to have attracted attention till recent times, and has only been proved by careful and well devised experiments and observations—though they have been known as far back as history goes.

The cause of the movement of glaciers is not evident. Some have attributed it simply to gravity, assuming that the sloping ground, on which the ice lies, allows it to slide down like a body on an inclined plane. This is not quite satisfactory, for if it slides down it ought to acquire momentum and a more rapid movement, but it does not. Others have attributed the movement to the daily expansion and contraction which the ice undergoes as it melts in sunshine and freezes in darkness. During the day the ice becomes partly filled with water melted on its surface, and at night this water freezes and expands, forcing the ice to move down the slope. The movement going on in winter when the ice does not melt as well as in summer, is an objection to this theory.

Others assert that as ice is capable of being moulded or pressed into different shapes without being crushed or broken into pieces, and as the ice of a glacier does fit itself to the valleys down which it descends, narrowing and widening as the valley narrows or widens and fitting itself perfectly to the inequalities of the surface, the explanation of the movement must be found in this property. And they say that the gentle slopes on which the ice moves are quite sufficient to produce the effects observed, or that even if the ground on which the glacier lies were flat and the upper surface of the ice inclined, as it is in all glaciers, there would be a movement from the higher surface towards the lower; just as a mass of pitch or thick fluid of any kind on a level surface slowly spreads out until its upper surface becomes itself level or flat.

Glaciers are formed from snow which accumulates in the valleys and other depressions of mountains, above the line of perpetual snow. Snow in these places becomes partially melted and wet in summer and then freezes in winter and finally be-

comes solid ice. The amount of ice which accumulates in this way is perfectly enormous—it becomes hundreds of feet thick. Professor Agassiz records sounding 700 feet down an opening in a glacier without reaching the bottom. These immense masses of ice press slowly forward and down the valleys, losing considerable thickness from the melting on their upper surface every summer, but not entirely melting for years or until they have passed down 2,000, 3,000 or even 4,000 feet below the line of perpetual snow. The glacier known as the Mer de Glace near Chamouni in Switzerland, has its lowest end at Bois only 3,680 feet above the sea level, while the line of perpetual snow is 8,500 feet high. In Norway at 60° north latitude the Nygaard glacier descends within 900 feet of the sea level, while the line of perpetual snow is 5,000 feet above that level, and in Greenland the glaciers come down to the sea though the line of perpetual snow is 2,900 feet above it.

The force with which these masses of ice move is beyond ordinary estimation. As they move down the valleys, rocks, stones and earth detached from the mountain and hillsides are continually falling on the ice and then moving on down with it. On the Mer de Glace a block of granite was seen this summer which was estimated to weigh 5,000 tons, and thousands of other blocks of all sizes from that down were to be seen. At the lower end of the glacier were immense piles of earth, stones and boulders which had been brought down by the glacier, and dropped as the ice melted from under them. The terminal moraine or pile of loose boulders, gravel and earth of that glacier is near 150 feet high. The glacier does not come against this now, but is back from it nearly 1,000 feet. Within 30 or 40 years, however, the glacier did extend to and against the moraine and pressed so hard as to cause it to move forward and the loose stones and boulders to roll down the slope in front, to the great danger and alarm of the village just below.

It is difficult to get a clear conception of the condition of things which would have allowed the whole surface to become covered with thick ice, when that surface was nearly as it is now, and some points are not satisfactorily explained. It can be understood, however, that extreme cold was not necessary, for we see forests, pastures and grain fields about the lower ends of the present glaciers. There has been found in the terrace of

modified drift at Trenton the tusk of a mastodon, which was evidently washed there when that mass of matter came down the valley of the Delaware with the torrents of water from the melting ice. It was about 14 feet under the surface, and the gravel and stones were partially stratified over it. From these the inference seems plain that the climate at that time admitted of the growth of animals like the elephant in size and habits. Whatever theories or hypotheses may be adopted in regard to glaciers, the piles and other deposits of loose boulders, gravel, sand and clay and the scratched rocks under them, which are found everywhere in Northern New Jersey, are wonderfully like the deposits which are made by modern glaciers, and there is scarcely a feature in one but what can be paralleled in the other.

SOUTHERN LIMIT OF THE GLACIAL DRIFT.

The southern limit, or boundary line, of the great terminal or frontal moraine as it has been traced across New Jersey, from the mouth of the Raritan river to the Delaware river at Belvidere, is described as follows, and is also marked on the State map accompanying this report:

The general course of the line from the Raritan is north-northwest to Morristown; thence, north to Denville; thence, westerly through Dover, across the Succasunna Plains (valley) over the Schooleys mountain table land to the Musconetcong valley, near Hackettstown; thence, west-southwest to Belvidere and the Delaware river.

At Perth Amboy the Raritan cuts the southern edge of the moraine and is the line of division between the glacial drift and the stratified sand and gravel drift, although it is not the northern limit of the latter formation. Perth Amboy also marks the extreme southern point of the moraine, as both to the east and also westward it trends towards the north. On Staten Island it is traced northeast, following the shore closely to Great Kills; thence, north-northeast to the foot of the serpentine ridge, and then, again leaving the latter to the left, on an east course to the Narrows. Westerly from Perth Amboy, the south line of the moraine follows the river to Eagleswood, where bending a little more towards the north, it crosses Crow's mill brook near the clay pits of the Woodbridge Clay Company, and then runs near

the clay pits of the Crossman Clay and Manufacturing Company to Ford's Corners, or Fairfield; thence to Metuchen its course is almost parallel to that of the Amboy and Metuchen road. From Metuchen the line runs a northerly course to Scotch Plains; and then a more northeast direction to the Springfield mountain which it meets near the Feltville and Westfield road. Across Middlesex county and to the Springfield mountain the line is traced with accuracy, as the surface inequalities of the moraine are in contrast with the plain country west and south of it. The red shale earth distinguishes it across the Plastic Clay Formation. This earth is the matrix in which are imbedded the angular stones, pebbles, cobblestones and boulders of shale and sandstone, of trap-rocks, of gneissic and other crystalline rocks, of Green Pond mountain sandstone and conglomerate, and of rocks from other more distant formations. The moraine here forms the well-known Short Hills, noted for their irregular slopes and lack of arrangement or order of grouping. These extend from Ford's Corners to Scotch Plains, and they attain a maximum elevation of 240 feet in Poplar Hill near the Woodbridge and New Brunswick road. There are several small ponds shut in among them, besides many swampy and wet basins—all without any apparent outlets. At many of the clay banks southwest of Woodbridge the excavations for clays, cut through the upper glacial drift and the lower stratified yellow sand and gravel drift. These show a general thickness of about 20 feet for the former, although in the higher hills it must be greater—probably 100 feet in the highest of them.

North of Scotch Plains the line ascends the mountain, and crossing it, descends a little into the valley between the two trap-rock ranges and meets the Second mountain just south of Summit. Here it makes a turn towards the west and crosses the Passaic near Stanley. The line is quite plainly seen on the First and Second mountains as on the south the trap-rock outcrops make a much more stony surface. On the north they have been buried under the boulders and boulder earth and the surface is more adapted to farm purposes. Along the Passaic river and west of Summit there are heavy banks and knolls of glacial drift, lying upon the foot of the Second mountain. The uneven surface east of Summit is also characteristic of the moraine and

known to all travellers over this part of the Delaware, Lackawanna and Western Railroad.

West of the Passaic river the moraine line is seen ascending and running northward up the side of Long Hill and sweeping around the north end of that ridge, about a quarter of a mile south of Chatham, and at an elevation of 350 feet. Scattered boulders are found 40 feet higher, but not to the top of the ridge, but the moraine is beautifully and distinctly traced over the end of the hill, and thence, southwest, on its western slope to the head of the more recent formation of the Great Swamp. From this point, on Long Hill the line pursues a northwest course, at the foot of the hills to Morristown. This range from Long Hill to Morristown is a prominent feature in the topography of that part of the country. It differs from the Short Hills in its more nearly level top towards the south, as if that edge of the moraine had been somewhat modified by the action of water, which has rearranged its materials.

This drift boundary line is plain through Morristown. Thence its course is northwest, west and then north, following the foot of the Highlands and at the western border of the Morris Plains to the Morris Plains station. Leaving the Plains, the Delaware, Lackawanna and Western Railroad line thence to Denville follows it quite closely. It is not, however, so well marked here as it is southward. Entering the Highlands it is somewhat obscured by the hills, some of which appear to have been high enough to rise above the upper surface of the ice, and, therefore, above the upper limit of the moraine.

Going westward from Denville there are some short gaps, which may have been caused by subsequent removal of the moraine at these points, or may have been original breaks in its continuity. The line is recognized on the north end of Snake Hill, where the drift mass appears wrapped around its northeast foot and rising upon it to a height of 670 feet. It is seen on the next ridge to the west and southeast of Rockaway. Thence southwest it appears in the valley of the Mill Brook south of the Rockaway. At Dover the moraine fills the valley and its southern limit winds around the northern base of the hills, through the town and over the point of Clinton Hill. Between Morristown and Dover there is a large proportion of Green Pond Mountain conglomerates and sandstones in the mo-

raine mass, and they assist greatly in tracing its limits since these stones are not so common south, whereas the gneissic fragments and weathered blocks are common over all the Highlands. These conglomerates and sandstones are not seen west of Drakesville. Their absence shows that the movement was not southwest but rather more to the southeast. At Dover the uneven—knoll and basin—structure appears. It is also characteristic of the terminal moraine through Port Oram and in the valley west to Drakesville. The boundary line on the south runs around the little hollow near the Dover R. C. Church and by the Jackson mine to Port Oram. Thence its course is southwest for about 2 miles, as far as the Scrub Oak mine, where it turns to the west and runs across the Morris canal to the McCainsville sandstone ridge. It bends around the north end of this ridge, attaining an elevation of 870 feet, and in a curving course returns to the hills at the Drakesville station. Here there is a gap where the line is not made out. It appears, however, about a mile to the westward, and thence is traced on the north of the Drakesville and Stanhope road for a mile, where it crosses that road and runs a general westerly course to the north shore of Budd's Lake. Thence it continues the same direction to the brow of the mountain, where it turns southward and descends obliquely down the mountain side into the Musconetcong valley. On the high land of Schooley's Mountain the moraine is a very marked feature in the topography, forming hills and hollows and having a wonderfully varied and uneven surface. And there is scarcely any stratification of the materials in them. They are confused heaps of earth, pebbles and boulders. The highest of these moraine summits are between 1,200 and 1,300 feet high—the highest points in the line of this moraine in the State. Here the blue limestones, slate rocks and boulders from the Kittatinny, or Blue Mountain, begin to appear more frequently and particularly west of Budd's Lake. One of these on the Osborne farm is so large that it has been a quarry for years past. In the Musconetcong valley we find the moraine pushed further south, and its limits not far from Hackettstown. The glacier extended itself further south in all the valleys which it encountered and left these tongues of drift further south than its line over the hills and table lands. And in this valley as in that of the Pequest also, the contrast between the plain surface

of the valleys south and that of the moraine north of our line, is very marked and attracts the attention of all familiar with the country. The same difference is very plain in crossing the hills from Hackettstown to Vienna or to Townsbury. The south line of the glacial drift runs about a mile north of Hackettstown across the Morris canal, and thence, in a course a few degrees south of west, over the hills across the Vienna road and to the Beatteystown and Danville road near the intersection of the Hackettstown and Mount Bethel road. Thence it runs south of the former mentioned road and turns southward and follows on the east side of the Pequest valley to a point one-third of a mile north of Amos Hoagland's residence. Turning to the west and northwest it runs thence to the creek at Townsbury. West of Hackettstown the moraine has a maximum elevation of 1,000 feet; in the Pequest valley the upper limit is about 600 feet. Beyond Townsbury the high crests of the Townsbury Mountain and the steep Frome's Hill seem to break up the moraine into detached bodies, and the line is traced with difficulty in a general southwest course and near the creek to the hills north of Oxford Furnace. It runs easterly from the valley of the Pequest and the Furnace brook, crossing the Butzville road to Oxford Furnace about a mile north of the latter place and then turns to the northwest and approaches a creek near Butzville. Thence its course is westerly and south of the stream until it enters the valley of the Delaware near and south of Bridgeville. In this valley also it makes a detour southward, and runs nearly to Oxford Church, following the western base of the gneissic rock mountain and the eastern border of the valley. From the last named point its further course is west-northwest across the blue limestone valley to the Pequest at Belvidere, where it meets the slate hills. This glacier appears to have reached its most southerly extension at this point in the Delaware valley, as to the west, in Pennsylvania the trend of the moraine is northwest to the valley of the Jacobus Creek and thence more westerly through Bangor to the Kittatinny Mountain near the Wind Gap.

Along the valley of the Pequest and that of Beaver Brook, south of the Jenny Jump Mountain, very much of the material of this moraine appears to have undergone a rearrangement and has been used in the formation of terraces which rise from that of the present flood plain to 405 feet above it. The upper limit

of the moraine as measured on the Manunka Chunk Mountain and other hills, and also in the valley at Belvidere is between 500 and 560 feet. From these and other like measurements it is possible to get at an approximate estimate for the thickness of the ice along this whole line. In another report it is proposed to describe more in detail this boundary line of the glacial drift and to give all the facts connected with this moraine and and from these to draw some conclusions in regard to the glacier itself.

That portion of the State, which lies north of the great terminal moraine is very generally covered by a glacial drift, and this drift constitutes the surface formation, excepting those tracts of wet meadows and some of the valleys and other lowlands, which are either alluvial and recent or belong to a post-glacial epoch. As the Continental glacier melted away at the south and retreated northward it left the materials carried on its surface and these were deposited somewhat as they had been grouped on the ice. A gradual recession strewed more or less the whole surface with the boulders and boulder earth, which made the mantle, or drift sheet, reposing upon the underlying rock formations. Whenever this retreat was for a time stopped and the glacier halted there was an increased accumulation at its foot, and thus a succession of terminal, or frontal moraines, but of limited extent, would be formed. The distribution of the glacial drift over this part of the State is very uneven. It is not a continuous formation, nor is there any uniformity in its thickness. And there are in many places no boulders and scarcely any boulder earth covering the rocks in place, or the earth derived from their disintegration and now constituting the surface layer. The higher hills and ridges—the peaks and crests are generally quite destitute of drift, excepting a few scattered boulders, and these even are wanting upon some of the higher points. The top of the Kittatinny, or Blue Mountain, many of the beautiful and smooth slate hills of the great Kittatinny valley, the crest of the Bearfort and Green Pond Mountains, Hickory Hill near Mount Hope, Sheep Hill, near Boonton and the trap-rock hills west of Paterson and many others, are all quite bare and show their rocks in many outcropping ledges. Others are so deeply covered that it is often difficult to ascertain the nature of the rocks in them.

The sheet of glacial drift is thicker upon the sides of the mountains and hills and the slopes of the drift on them are generally quite uniform and more gentle than those of the internal rock mass. That is, the accumulation of drift is thicker near the bases. In many cases these drift slopes are quite as regular and uniform as are seen in the smoother country south of the limit of this formation. The glaciated stone and erratics point to its origin and leave no doubt as to whence it came.

The drift in the lowlands and valleys is much more uneven and looks more like that of the frontal moraine. And in some localities there are immense heaps—rising into hills and ridges—of earth, gravel, cobblestones and boulders, which mark lines along which the glacier may have halted for a time, or to which it may have again advanced and heaped up the loose materials in front of it. One of the most beautiful of these later moraines, is that which stretches across the valley of the Wallkill at Ogdensburg in Sussex county. In fact, the village is on it. There is a great bank of earth and boulders, &c., stretching from the gneissic slopes on the east to the white limestone of the Pimple Hills range on the west. This bank, or ridge, has a convex southward front showing that it was left here by a glacier which moved southward up the valley of the Wallkill. It is interrupted at the west side of the valley by a gorge or gap through which the kill now flows. It is about 100 feet high above the valley level north of it and above the creek in the gap.

At Hamburgh there are some very large hills of drift lying near the southern end of the Vernon valley. And these with others near McAfee valley look as if they had been left there by a glacier which moved down, southwestward through the Vernon valley. Another well marked moraine is at the north end of Green Pond, which stretches across what seems to have been the former outlet to that lake.

In the valley of the Rockaway near the Sparta turnpike there is a group of flat-topped hills which fill the valley, excepting the narrow depression winding through them in which the Rockaway finds its way. Similar hills are seen in the same valley further to the north and near the Pequannock.

The valley of the Passaic is very full of drift. East of Montville large and heavy banks of drift are cut into by the Boonton branch of the Delaware, Lackawanna and Western Railroad.

And to the northeast there are hills along on both the east and west sides of the Pompton Plains. These appear to be very nearly of the same height and are, apparently, of the same age and the deposits of one agency. The hills about the Ponds neighborhood and Oakland in Bergen county are also of glacial drift. At Allendale, and thence to Sufferns, there is a great thickness of the drift, entirely concealing the underlying red sandstone. On the eastern border of the same—red sandstone valley—between Demarest's station and the State line, there is an irregular line of hills lying at the base of the Palisades Mountain. These latter are not frontal moraines, but more like the lateral, or side moraines, or, possibly, accumulations which took place under the glacier, as part of a bottom, or ground moraine.

Many other such drift hills and ridges have been examined. and they might be added to this list, but those above mentioned illustrate their nature and show how widely they are distributed. In a future report they will be described in all their relations and be mapped so that it shall be possible to indicate the probable source of their material and the movement of the ice mass as learned from their composition and structure.

In many of the larger valleys the drift is stratified and there are flat-topped hills and banks of earth, gravel and boulders—evidently the result of the action of water. Such terrace hills and shelves are common along the Delaware valley, west of the Kittatinny, or Blue Mountain, in the valley of the Paulinskill, and more or less throughout the whole extent of the Kittatinny valley. There are beautiful sand and gravel flats along the Horse Pond brook, northeast of Rockaway; along the Rockaway, between Denville and Powerville; along the Wynokie, or Ringwood creek; Pompton Plains; the lowlands bordering the Passaic river, above Little Falls; and along the Saddle river and the Hackensack river in Bergen county. These are all north of the glacial drift limit and they must at some time have been covered by that formation. In many of them the older drift has been in part worked over and sorted by water and, in part, covered by these stratified, or sorted deposits. Some of these have been lake basins, which are yet only partially drained.

There are a number of terraces, on ground open towards the

sea, which have their upper surfaces almost at equal heights above tide level. The terrace on both sides of the Pennsylvania railroad, near Trenton depot, is one of them. It is between 50 and 60 feet high. The gravel bed at the railway depot at New Brunswick and also that on Bayard street are nearly the same level. The terraces at the Narrows in New York harbor are also on the same level, and others along the west bank of the Passaic, in Newark, are of nearly the same height. It can also be recognized along Bergen Hill, both on the North river and the Newark bay sides. Up the North river, near Peekskill, similar terraces are very conspicuous, but their height above tide is about 90 feet. In New Jersey, in the more southern part, terraces are seen, but they are at a somewhat lower level. The whole of them, taken together, indicate that at some former time, perhaps at the close of the glacial period, the ocean level was somewhat higher than it is now, enough higher to bring it just over the tops of these terraces, and water bringing stones and earth from the higher ground would deposit them when it reached sea level, in these steep flat-topped terraces. The terrace at Trenton is just where the valley of the Delaware comes down to this level, and where it widens out to allow room for such a deposit to accumulate. These are good examples of terraces of the Champlain Period.

There are also some well marked and large sand banks a few rods south of the terminal moraine at New Providence, in Union county, and at Townsbury and Oxford, in Warren county, which appear as if the glacier had terminated in water and these sand deposits had been washed out of the coarser and unsorted materials brought there with it, and deposited in these banks.

2. PRELIMINARY DESCRIPTION AND CLASSIFICATION OF THE SOILS OF NEW JERSEY.

The soil is that surface coating of the earth which is capable of supporting vegetation, and when cultivated, of producing crops. It is usually but a few inches in thickness, and is always characterized by containing a little decaying vegetable matter which gives it a color somewhat darker than the earth or subsoil under it. It also differs from the subsoil in its consistency, being more mellow and crumbling.

However different the soil from the subsoil under it both are derived from the same materials, that is from the rocks underlying them, or from the sands, gravels and clays upon those rocks. The difference has been produced by the long continued action of air and moisture, the varying temperatures of the year, and the action of the growing and decaying vegetation upon the mineral substances of the earth or rock surface. It is only necessary to examine a pile of earth, crumbled rock, or even of cinders or broken bricks, which has been exposed to the weather for a few years, and the beginnings of a soil will be seen—fine particles have gathered in protected places, weeds, grass, and perhaps trees have begun to grow in it, and it is taking the dark color and mellow consistency of a soil. And this change will go on until the coating of soil is so thick that the agencies of change can no longer act. Soils made in this way can be seen on the embankments of any of our older railroads or canals. There is one near New Brunswick made entirely of red shale about forty years ago, which now has the mold or soil on it two to four inches deep, and is covered with grass, bushes and some trees. The cinder heaps at Oxford which may be fifty or sixty years old, have some large trees on them, grass is growing in patches, and they promise to be soon entirely covered with soil. In looking at the cut edge of any excavation the several layers of soil, subsoil and underlying rock or earthy material are plainly seen, and the change from one to the other may be studied and compre-

hended. The nature of the changes which the underlying rocks or earth have been subjected to are various. In the granitic and crystalline rocks there has been a decomposition by which the feldspar has become clay, the quartz is sand, and the mica or hornblende is a more or less reddish sandy earth. On the limestone rocks, the soil has been made by the slow dissolving of the carbonate of lime in water, and leaving as a sediment the original impurities of the rock to cover the surface and constitute a soil. Slates crumble down fine and make a clayey soil with very little chemical change from the original rock. Other kinds of rock, by their crumbling or decay, produce soils of different qualities.

As soils then are formed from rocks, they must necessarily have some qualities in common with the rocks, and in any particular district or country the easiest and most systematic classification of soils is based on its geological structure.

The designation of soils as sandy, loamy or clayey is common in all countries, and conveys some idea of their consistency, but it is merely a comparison of soils on the same farm or in the same neighborhood. As applied in different parts of New Jersey the terms are very inaccurate; that which is called a clayey soil in the southern end of the State, would be called a sandy soil at the north. Such a classification also gives no information as to the composition or capabilities of a soil. On the contrary, a classification of soils based on their geological origin does give some idea of the nature and promise of the soil, even if its surface materials have been somewhat sorted by rains, so as to leave it more sandy in some places, and more clayey in others.

A classification of our New Jersey soils may include the following kinds, viz:

Granitic soils.
Limestone soils.
Slate soils.
Red sandstone and shale soils.
Trap rock soils.
Clay district soils.
Drift soils.
Marl region soils.
Tertiary soils.
Alluvial soils.

The portion of New Jersey southeast of the marl district and covering two-fifths of its surface, has not been considered so fertile as other parts of the State, and more than three-fourths of it is still in forest. There are large tracts of it, however, especially in Cumberland county, which are in a state of high cultivation, and are productive and profitable.

The general geological structure or division of the State into belts which traverse it in a northeast and southwest direction, prevails in this part the same as in the north and west, but the strata are nearly horizontal, and being not very thick, the wash of rains and the drainage of the country, which is by streams running south, southeast and east, has cut across and through the strata in such a way as to present characteristic soils in broad belts or tracts, running from the northwest towards the east, southeast and south.

The geological strata exposed in this part of the State consist of thick beds of white sand, some of which are of excellent quality for glass-makers' use—of beds of marly earth, some of which are used for fertilizers—and of a thick deposit of gravelly loam, which originally overlaid the others, and still occupies the highest grounds.

The soils of this portion of the State then, are gravelly loams, and white sands, or from the trees on them the lands may be designated as oak lands and pine lands, and the intermediate as oak and pine lands.

An attempt is made on an accompanying map to designate approximately these varieties of land in Southern New Jersey. The accurate mapping out of these different soils will be of much value. It will prevent the attempt to clear up and cultivate the white sands which are really almost worthless for cultivation, and should be kept in forest. The gravelly and sandy loams may be cleared up to the profit of the settler, and the benefit of the State. And when that is done, and the tracts of good land are opened throughout, the tracts of woodland will be to some extent isolated and protected from the sweeping fires which now destroy large bodies of timber, and render property in forests so uncertain that it loses more than half its real value.

The map accompanying this report has on it the approximate outlines of the different belts of pine and oak lands, into which southeastern New Jersey is divided. There will be found many

limited exceptions to these bounds, and the map must only be considered as a first attempt, put forth with the hope of bringing together on a later one, the facts now scattered among many observers, and which can easiest be secured by the criticism and correction of this map.

1. HOMINY HILLS PINE LANDS.

The most northerly of these belts of pine land is in Monmouth county. It runs west and north of west from the ocean, north of Shark river and south of Poplar to the Hominy Hills in Atlantic township. It is crossed by the New Jersey Southern Railroad between Eatontown and Shark river, and also by the Colt's Neck and Farmingdale road. It is at least 10 miles long and from 2 to 4 miles wide. There are several quite high hills in it, as the Cranberry Hill, which is 178 feet high, and the range known as the Hominy Hills. The surface is somewhat rolling, although a part of it is rather flat and wet. Isolated and small clearings have been made, but the greater part is a white sand and white sandy gravel surface which is covered with huckleberry bushes and scrubby pine trees. Frequent fires run over much of the timbered area so that the wood on it is of comparatively little value. The contrast between this belt and the rich farm lands of the marl districts on each side of it is very marked and tends to depreciate it. A careful survey will, no doubt, indicate parts of this belt which are capable of profitable clearing and farming.

2. SQUANKUM OAK LANDS.

South of the above described belt are the heavier soils of New Bedford, Squan and the country along the north bank of the Manasquan river, forming a continuous belt westward to Blue Ball and the more thickly settled parts of Monmouth county. The lands of this belt are largely in farms as can be seen along the Freehold and Squan Railroad, which traverses it lengthwise. Convenience to the marl outcrops has greatly promoted the clearing up of these lands.

3. MANASQUAN RIVER PINE LANDS.

Going southward on the line of the New Jersey Southern Rail-

road a narrow belt of pine land is crossed north of Bricksburg and south of the Squankum Belt. It is said to be connected on the southeast with the sands between the Manasquan river and Burrsville. The Squan and Burrsville road crosses it near the shore. There it is a coarse white sand. West of the railroad it runs northwest along the upper part of the north branch of the Metedeconk river. At present nearly all of this belt is in pine and oak forest. On account of its nearness to railroad communications and to marls much of its surface may yet be profitably cleared and farmed.

4. BRICKSBURG OAK LANDS.

The next belt on the south is that of Bricksburg and Bennett's Mills. It has the south branch of the Metedeconk for its southern limit. The lands about Jackson's Mills are also included in it. Its extension beyond Bricksburg towards Burrsville has not been traced. The sands along the road from Squan to Toms River seem to cut off the eastern end and connect the last described pine belt with that south of this belt. The best lands of the Bricksburg Land and Improvement Company, lying north of the Metedeconk and northwest of the village are in this belt. The good natural soils of this belt, their accessibility to railroad communication and the rich marls of Squankum, not too far away for team transportation, will soon cause nearly all of it to be cleared and made into farms.

5. BRICKSBURG PINE LANDS.

This belt of pine land, which is so plainly defined by the creek at Bricksburg and the high grounds on the south, near Mount's crossing and the old Seven Stars site, runs eastward to the headwaters of Barnegat bay. From the New Jersey Southern Railroad to the bay its length is eight miles. It is two to three miles wide. Some of the clearings of the Bricksburg farmers, south of the village, are on it. Excepting these, it is all in forest and nearly all of it yellow pine timber. Analysis number 14 of table of analyses shows the chemical composition of the poorest of the white sand soils of this belt.

6. TOMS RIVER OAK LANDS.

Parallel to the last mentioned belt and bordering it on the south is what may be termed the Toms River belt of oak lands. The most southern farms on the Bricksburg tract, the white oak bottom lands and the farming country north of Toms River are in this belt. Its northwest extension is crossed on the line of the New Jersey Southern Railroad, between Mount's Crossing and the Ridgeway Branch. White's bridge and Ridgeway stations are in it. Beyond these points it extends towards Goshen and Vanhiseville, in Jackson township. Its boundary on the northeast coincides with that of the higher grounds and runs east of Cedar Grove and northeast of White Oak Bottom. On the southwest it stops at the Toms River. As the belt has not been followed to its west end the length is undetermined. It is three or four miles wide. Its surface is somewhat undulating and much of it between 50 and 120 feet above tide level. The soils contain some clay and very generally some gravel. A large part of it east of the railroad is now in farms and one of the best farming districts of Ocean county is on it and near the old Freehold road north of Toms River. The analyses Nos. 8, 9 and 10, of table, show the natural richness of these soils as compared with those of the pine land belts. Wherever there are woods the oaks are seen mixed with the yellow pine. The nearness to transportation and the supply of natural fertilizers are advantages, which must tend to the clearing up and cultivation of these lands.

7. TOMS RIVER PINE LANDS.

South of Toms River there is another belt of pine land. Its limits are not at present known, except that it stretches from the Bay shore westward to Manchester and thence into Jackson township. The roads from Toms River to Double Trouble, Dover and the Toms River Branch Railroad cross it. Along the New Jersey Southern Railroad it is five to six miles wide—from the Ridgeway Branch nearly to Whitings Station. This belt is rather low, although there are some hills and ridges, south of Toms River. There are some fairly good soils under cultivation on the Manchester Company's tract, and careful surveys will doubtless show that much of it is capable of permanent improvement and will make farms. Very much the larger part of it is now covered

by yellow pine of second growth and stunted by frequent fires. Analyses Nos. 16 and 17 of the table show the composition of the lightest of these sands.

8. LACEY OAK LANDS.

Going southward, the clearings at Forked River, Lacey, Bamber and Whiting's stations, indicate an east and west strip, or belt, of better land. The road from Forked River to Bamber, and thence to Whiting's runs through it and gives an impression of it. The breadth does not exceed four miles. It cannot be given accurately, as on the south this belt appears to merge itself gradually into the next belt of pine lands. Gravelly soils prevail, and the vineyards of Lacey, Forked River and Bamber are on these. The cleared areas are still small and confined to the vicinity of the villages above mentioned. The timber is pine and oak mixed.

9. FORKED RIVER PINE LANDS.

The pine lands belt, which lies southwest of Forked River, west of Waretown and south of Bamber and Whiting's, appears more irregular in its outlines, although at present, these seem almost undefined. It is traversed by Guise's road, the Webb's Mill road, and the Balcony road, and by the Tuckerton Railroad between Waretown Junction and the neighborhood of Bamber. Towards the west it is crossed, near Hanover, by the railroad to New Lisbon. There are hardly any clearings in this belt, and the timber is scrubby pine, with cedar swamps in the wet grounds along the streams.

10. CEDAR BRIDGE OAK LANDS.

The next alternating belt of country is one of heavier soils, and its boundaries on the south are better defined. The Mannahawken creek and then the Cedar Bridge and Red Oak Grove road are near its southern margin. The Forked River Mountains are on the north—also Wells' mills. Wheatland is on it, and the road thence to Cedar Bridge and Barnegat runs through it. From the bay to the New Jersey Southern Railroad, west of which it has not been traced; it is sixteen miles long. It has

an average breadth of four miles. The surface is from 50 to 200 feet above tide-level, and is the water shed between Oyster and Cedar creeks on the north, and the branches of Wading river on the south. The soil of the higher portions is gravelly loam, quite clayey in spots. The hill slopes are more sandy—while the hollows are more loamy. Oaks and pines make up the forests, which now cover all of it, except the small areas of a few farms at each of the above named places. An analysis of quite stiff, gravelly-clay loam, from the Cedar Bridge roadside, west of Barnegat, shows the character of the better grades of natural soils and subsoils. South of this belt we come to a broad district of pine lands, which may be provisionally termed

11. THE BURLINGTON PLAINS PINE LANDS.

It is the broadest belt and includes within its bounds some of the poorest lands in the State. It is represented as extending to the Atsion river—on the southwest—a distance of fifteen miles and comprising a large part of the country drained by the Wading river. On its eastern side there are the well known barrens of East Plains and West Plains—several thousands of acres destitute of timber and covered by low shrubs and dwarf pines. On the west side of the New Jersey Southern Railroad this belt is said to extend quite to the marl districts, so that it includes in its bounds much of eastern Burlington. Along the shore there is a narrow strip of farm land from Mannahawkin, Tuckerton, New Gretna and Bass River to Egg Harbor. Excepting this shore strip and a few farms about Shamong and Woodmansie, the whole belt is an unbroken wilderness of fire-scarred, scrubby pines. The surface is generally coarse white sand and white, sandy gravel. In some places, as on the Plains, the subsoil is quite heavy and apparently capable of improvements, but the soils, in general, are too light for profitable farming. Towards the southwest this belt joins the Atsion River Pine Lands belt.

12. ATSION RIVER OAK LANDS.

This is a wedge-shaped belt, which follows the northeast bank of the river, by Atsion, and there widens out and includes within its bounds the cleared lands of Shamong and Tabernacle. It is

narrow below Atsion. At present its limits are somewhat doubtful and are left undefined. A considerable area about Atsion is under cultivation.

13. ATSION RIVER PINE LANDS.

This is a narrow strip of pine lands on the south of the Atsion river. It is crossed by the New Jersey Southern Railroad between Atsion and Atco, and Atsion and the Bates mill branch of that stream. The northwestern end of this belt is north of Jackson and in the townships of Evesham and Medford. A part of the Hammonton tract and the northern part of the Egg Harbor tract are included within its boundaries.

14. RAILWAY OAK LANDS.

The clearings and farm lands of Atco, Winslow, Hammonton, Elwood and Egg Harbor City, indicate a belt of heavier soil, extending from the marl district southeast through the eastern part of Camden and across Atlantic county to tide water. The lines of railroads to Atlantic City run through the central portion of this belt and hence its designation as the railway belt. It is one of the largest of these oak lands districts and the larger part of it is still in forest. The timber is oak and pine mixed. The success which has attended the settlements above mentioned, indicate the natural adaptation of these lands to the purposes of farming, and its railway facilities have made it easily accessible and given it good communication with Philadelphia and New York markets.

15. GREAT EGG HARBOR RIVER PINE LANDS.

This belt bounds the Railway oak lands belt on the south. It can be traced from near the mouth of this stream for twenty-five miles through Atlantic and into Camden county. It is between two and three miles wide, and below Weymouth, is confined mostly to the eastern side of the river. It takes in the Penny Pot sands, south of Winslow, and extends northwest almost to Williamstown. On account of its nearness to tide-water much of this belt has been cleared, as at Mays Landing and Weymouth, and a little of the extreme southern part of the Ham-

monton tract. There is not much white gravel on the surface, but nearly everywhere white sand, which is in contrast with the better soils of the belts on each side of it.

16. OAK LANDS OF THE ATLANTIC AND DELAWARE BAY DIVIDE.

This district comprises nearly the whole area between the Great Egg Harbor and the Maurice rivers. It constitutes the southwestern part of Atlantic county and the eastern part of Cumberland. About one-third of the latter is in it. The New Jersey Southern Railroad crosses it between Cedar Lake and Vineland, and the old stage road through Cross Keys to Tuckahoe runs through it. The road from Mays Landing to Vineland crosses it, as does the Manumuskin and Tuckahoe road. The soil is characterized as a gravelly loam. Its natural excellence and adaptation to farming is shown by farms and settlements within its limits, as also by the size and thriftiness of the oak and pine timber. The soils of Vineland are on it, as are those of Forest Grove and some good farms near Leaming's Mills, Manumuskin, Estelleville and Tuckahoe.

17. MAURICE RIVER PINE LANDS.

This name is given to the long and narrow strip of sandy land which borders the Maurice river from Malaga to Port Elizabeth, and thence extends southeasterly, on both sides of the Millville and Cape May Railroad quite to the Cape May county line. It is confined almost wholly to the east side of the river at Vineland, and is from one to two miles wide. At Millville it is two miles wide. To the south it widens, reaching nearly to Cumberland Furnace. At Belle Plain its breadth is said to be five or six miles. The length from Malaga to the county line is not quite 30 miles. Like the Great Egg Harbor river belt it appears to be dependent upon the topography of the country, and it includes the lowlands along the river. Rising on the higher grounds, both on the east and on the west its limits are crossed, and a heavier, gravelly loam soil is reached. The surface of this belt is, in general, excessively poor, consisting of coarse white sand, with very little loam and scarcely any vegetable matter. Where the sand is finer grained, and the loam admixture is larger, the soils are better. Some of these have been cleared and

farmed; others have been abandoned as unprofitable soils. With large areas of good land in the oak belts on each side of this Maurice River belt, equally accessible, and offered at equally low prices, it is not desirable for settlers to attempt the clearing and farming of these white sand soils. They are needed to produce wood for the better lands and for climatic reasons.

18. CAPE MAY OAK LANDS.

The county of Cape May is all fairly included in the oak-growing lands. The soil is alluvial in character, of good quality, and, when well farmed, productive. The clearings have been mostly confined to those parts bordering on the Atlantic or on Delaware Bay, and the greater part of the county is still in woods. Its distance from markets, has heretofore prevented its being cleared up rapidly, but now that it is opened by convenient railroad communications with both New York and Philadelphia it offers great inducements to settlers.

19. THE SALEM BARRENS PINE LANDS.

The only other tract or belt of white sand which has been traced out, is that which is generally known as the "Barrens," in Salem county. It is west of Stow creek and northwest of Shiloh and Jericho. It is of quite limited extent, being about 2 miles wide and not more than 8 miles long—from northeast to southwest. It is covered by yellow pine timber and of better quality than much of the timber further northeast, and has some good oak timber on it. The sand of the surface layer is dug and taken to Bridgeton and Quinton for making glass.

The area occupied by these belts of land may be set down approximately as follows:

		ACRES.	
		PINE LANDS.	OAK LANDS.
1	Hominy Hills Pine Lands	20,000	
2	Squankum Oak Lands		45,000
3	Manasquan River Pine Lands	20,000	
4	Bricksburg Oak Lands		10,000
5	Bricksburg Pine Lands	15,000	
6	Toms River Oak Lands		50,000
7	Toms River Pine Lands	70,000	
8	Lacey Oak Lands		40,000
9	Forked River Pine Lands	50,000	
10	Cedar Bridge Oak Lands		40,000
11	Burlington Plains Pine Lands	240,000	
12	Atsion River Oak Lands		35,000
13	Atsion River Pine Lands	60,000	
14	Railway Oak Lands		200,000
15	Great Egg Harbor River Pine Lands	55,000	
16	Divide of Ocean and Bay Oak Lands		230,000
17	Maurice River Pine Lands	50,000	
18	Cape May Oak Lands		100,000
19	Salem Barrens Pine Lands	10,000	
		590,000	750,000

There are in addition to the above oak lands, the tract on the west side of Maurice river in Cumberland, Gloucester and Salem counties, which contains 240,000 acres, and the total area is 1,580,000 acres, of which 350,000 acres are now in farms, leaving 1,230,000 acres still uncleared, of which the oak lands fit for clearing, amount to 640,000 acres.

The country included in the above area occupies all the Southern and Eastern portion of the State. It borders on the Atlantic from Deal to Cape May, and on Delaware bay from the mouth of Maurice river to the ocean. On the north and west it is limited by the marl region, and the high grounds which make the back bone of the State. It is 100 miles long from north to south, and 35 miles wide from east to west.

The climate is mild, the mean temperature of the summer months at Vineland for 3½ years being 75½ degrees Fahrenheit, and the mean winter temperature 32 degrees Fahrenheit. And the extremes from these are not large.

The annual rainfall is 48 46-100ths inches, which is pretty evenly distributed through the year. Very little snow falls, and the winters are so mild that plowing can be done every month in the year.

The climate is salubrious, and has been specially noted by its

entire freedom from malarial influences. It is specially liked by those who suffer from asthmatic and pulmonary diseases; and many come here for the relief they obtain from such ailments. The sea-side resorts are continually increasing in number and enlarging in size; and throngs of visitors come to enjoy the delightful air.

The water of this country is pure and soft. It is drained by many large rivers which are chiefly remarkable for their full and equable flow, being very little affected by storms or by drouths. They furnish excellent water power for manufacturers' purposes. Those at Mays Landing, Weymouth, Batsto, Atsion, Millville, Bricksburg, Manchester and Toms River, are of this kind, and there are a great many other good ones.

The soil is light but easily cultivated, and when well managed is productive. Mr. Hay's farm, at Winslow, is a model of productiveness for all South Jersey. The improved lands at Vineland, Hammonton, and Egg Harbor City, are yielding large crops and promise well for the future.

The staple productions are wheat, rye, oats, Indian corn, hay, potatoes and sweet potatoes. Melons are raised in abundance. Apples, pears, peaches, grapes, blackberries, raspberries, strawberries and currants grow remarkably well.

The means of communication are good. There is an abundance of gravel for road making, and the benefits of good roads are highly appreciated. Cumberland county claims to have more good roads than any other county in the State. The West Jersey Railroad, the Glassboro and Millville, the Millville and Cape May, the New Jersey Southern, the Camden and Atlantic, the Philadelphia and Atlantic City, the Mays Landing branch, the Pemberton and Manchester, the Tuckerton, the Toms River branch, the Toms River and Waretown, and the Freehold and Squankum branch to Squan are all railroads in this district, and every point in it is within an easy drive of railway communication, and, by this, is within three or four hours ride of the best markets on the continent.

The following table of the analyses of soils is presented as a beginning of the work that needs to be done in this direction. It is not complete geographically, and is not full enough to be taken as an average of the soils. But it is all that could be done up to this time, and it is hoped that its imperfections and deficiencies may be corrected and filled up hereafter.

ANALYSES OF SOILS.

Soils and Subsoils from Granitic Formations.

		Water. (Moisture.)	Sand. (Insoluble in acid.)	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Carbonic Acid.	Organic Matter.	Total.	Nitrogen.
1	Subsoil, Flanders, Morris county	2.300	63.300	16.490	9.200	0 252	0.070	0.041	0.198	traces	traces	....	8.500	100.351	0.044
2	Soil, Washington, Warren county	1.550	72.250	19.573		0.312	0.130	0.014	0.127	0.005	0.002	0.019	5.850	99.832	0 034
3	Soil, Pohatcong Mountain, Warren county	2.000	63.800	16.150	8.840	0.504	0.190	0.120	0.154	traces	0.017	0.014	8.850	100.640	0.220

Magnesian Limestone Subsoil.

		Water. (Moisture.)	Sand. (Insoluble in acid.)	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Carbonic Acid.	Organic Matter.	Total.	Nitrogen.
4	Subsoil, Johnsonsburg, Warren county	1.400	70.160	3.877	5.016	0.576	0.240	4.235	0.307	traces	traces	5.380	8.050	99.241	0.131

Soils from the Trap Rock Ranges.

		Water. (Moisture.)	Sand. (Insoluble in acid.)	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Carbonic Acid.	Organic Matter.	Total.	Nitrogen.
5	Soil, Palisades Mountains, Bergen county	3.700	76.300	6.186	8.510	0.288	0.145	0.140	0.089	0.004	0.012	0.150	4.750	100.274	0.041
6	Soil, Ten Mile Run Mountain, Middlesex county	3.2[illegible]0	52.200	23.050	11.320	0.304	0.190	0.120	0.077	traces	0.020	0.025	9.500	100.056	0.023
7	Soil, Rocky Hill, Mercer county	1.650	72.200	18.370		0.302	0.130	0.100	0.131	0.014	traces	0.029	7.000	99.926	0.051

Soils and Subsoils from the Oak Lands of Southeastern New Jersey.

		Water. (Moisture.)	Sand. (Insoluble in acid.)	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Carbonic Acid.	Organic Matter.	Total.	Nitrogen.
8	Soil, White Oak Bottom, Ocean county	1.500	89.250	4.797	2.014	0.216	0.080	0.015	0.084	0.005	trace	0.017	2.300	100.278	0.035
9	Soil, Geo. W. Cowperthwaite, Toms River	0.350	94.300	1.070	1.400	0.252	0.040	0.021	0.031	0.021	0.002	....	2.150	99.640	0.042
10	Subsoil, Under No. 9	0.450	92.450	1.814	1.908	0.200	0.045	0.014	0.020	0.012	....	....	2.250	99.220	0.028
11	Soil, East of Whiting's, Ocean county	0.250	94.500	1.705	1.870	0.114	0.025	0.007	0.025	traces	traces	0.017	1.650	100.160	0.027
12	Subsoil, Cedar Bridge road, Ocean county	1.150	83.180	8.375	3.099	0 076	0.055	0.005	0.026	0.0014	0.0017	....	3.950	99.921	....
13	Soil, Egg Harbor City	0.225	96.160	1.206	0.796	0.056	0.036	0.011	0.019	0.0008	traces	....	1.375	99.885	0.018

ANALYSES OF SOILS—(*Continued*).

Soils and Subsoils from the Pine Lands of Southeastern New Jersey.

No.		Water (Moisture)	Sand. (Insoluble in acid.)	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Carbonic Acid.	Organic Matter.	Total.	Nitrogen.
14	Soil, Bricksburg tract	0.100	98.910	0.293	0.067	....	0.001	0.0017	traces	traces	traces	....	0.700	100.093	....
15	Soil, Dillon's Island, Toms River	0.250	98.590	0.212	0.248	trace	trace	trace	trace	traces	trace	....	0.650	99.950	0.017
16	Soil, Two miles south of Toms River	....	99.420	0.318	0.024	0.010	0.014	trace	0.018	trace	....	....	0.200	100.000	....
17	Subsoil, Under No. 16	0.500	98.120	0.472	0.510	0.011	0.007	0.018	0.028	....	traces	traces	0.250	99.916	0.014
18	Soil, East Plains	0.200	98.440	0.269	0.452	traces	0.035	0.025	0.038	0.0007	0.0005	....	0.200	99.660	....
19	Subsoil, Under No. 18	0.200	97.020	0.663	0.792	0.054	0.031	0.012	0.045	0.017	traces	....	1.050	99.884	....

Soils from the Intermediate Oak and Pine Lands of Southeastern New Jersey

No.		Water (Moisture)	Sand. (Insoluble in acid.)	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Carbonic Acid.	Organic Matter.	Total.	Nitrogen.
20	Soil, Dr. T. T. Price, Tuckerton	0.300	97.460	0.427	0.230	0.014	0.033	0.012	0.023	0.0017	traces	....	1.500	100.000	0.015
21	Soil, Mauricetown	0.850	94.440	2.489		0.050	0.040	0.017	0.031	0.0007	0.0013	....	1.975	99.890	0.080
22	Soil (No. 1), Thorofare, Gloucester county	0.400	96.050	0.904	0.860	0.065	0.095	0.105	0.106	0.024	....	....	1.330	99.940	0.053
23	Soil (No. 2), Thorofare, Gloucester county	0.450	94.200	0.624	1.080	0.132	0.133	0.110	0.096	0.027	....	....	8.600	100.450	0.083

GRANITIC SOILS.

1. Subsoil, Flanders, Morris county. The specimen was taken from the roadside, south of the village. Reddish in color. Contains some undecomposed and other partially decomposed rock fragments.

2. Soil from Washington, Warren county. This specimen was obtained near the village and on the side of the road to Oxford Furnace. It is yellowish red in color and free from pebbles. Contains some small rock fragments. It represents the natural red soils which are common in the valleys of the northern part of the State.

3. Soil from the summit of Pohatcong Mountain, on New Hampton and Pleasant Valley road, Warren county.

The specimen came from the road side. It is reddish in color. A few small fragments of gneiss, much decomposed, in it. It is derived from the gneiss.

MAGNESIAN LIMESTONE SUBSOIL.

4. Subsoil from side of Long Bridge road, one mile southeast of Johnsonsburg, Warren county. Brownish color. The earth is mixed with the blue limestone in small, angular pieces. It is a representative of the red soils which are seen in many places overlying the limestone formation. This subsoil is close to the rock in place. It makes a good soil.

SOILS FROM THE TRAP ROCK RIDGES.

5. Soil from Woodland on the top of the Palisades Mountain, near the New York line, Bergen county. Brown; contains a little fine gravel and some decomposed rock fragments. It appears to have been derived mostly from the trap rock underlying it, but mixed with this earth and rock there is a little drift material. This soil is retentive and supports a heavy growth of timber.

6. Soil from the side of the county line road, 1½ miles northeast of Kingston, Mercer county. Yellowish color. Very little rock in it. Soil here is close to the trap rock and is derived from its decomposition. It makes a good soil, but rather tight bottom.

7. Soil from the top of Rocky Hill, 2 miles north of Princeton, Mercer county. Yellowish color; much like the last. It is derived from the weathering of the trap rock of the hill and well represents soils of such origin.

SOILS AND SUBSOILS FROM THE OAK LANDS OF SOUTHEASTERN NEW JERSEY.

8. A yellow sandy loam containing some gravel. It is from the side of road, in woods, near White Oak Bottom, and three miles south of Bricksburg, Ocean county. Specimen represents one foot from surface downward. Timber mostly oak. This represents the clayey and gravelly loams of the southern part of the Bricksburg tract and some of the White Oak Bottom soils.

9. Soil from farm of George W. Cowperthwaite, Toms River, Ocean county. The specimen is greyish in color; contains a small proportion of coarse sand and small pebbles. It represents the natural soil of the oak lands near and north of the village of Toms River.

10. Subsoil under the last named; yellowish, some small pebbles in it.

11. Soil, one mile east of Whiting's Station, Ocean county. This soil was obtained from woodland near the Bamber road. It was ten inches thick and underlaid by a yellow, sandy subsoil. Some fine roots in the sample. Timber of locality is second growth oak, with a little yellow pine.

12. Subsoil from Cedar Bridge road, about three miles west of Barnegat, Ocean county. Reddish color. An unusually heavy subsoil for this part of the State. It contains no gravel. It represents the best of the clayey subsoils—especially those which are free from gravel—of Southeastern New Jersey. Locality is in woods (oak and few scattered pines).

13. Soil from vineyard of Julius Hincke, Egg Harbor City, Atlantic county. Ash-colored, sandy loam, containing some quartz pebbles. Unmanured. This specimen represents the natural soil, which is said to be adapted to grape growing.

SOILS AND SUBSOILS FROM THE PINE LANDS OF SOUTHEASTERN NEW JERSEY.

14. Soil from woods on Bricksburg tract, about two miles southeast of the s ation. The specimen represents one foot sec-

tion of the surface and the poorest of the soils in this pine lands belt. It is coarse white sand, with some fine rootlets. The timber consists of a few scattered and shrubby pine trees. Under this sand there is a yellow, sandy subsoil.

15. Soil from Dillon's Island, Toms River, Ocean county. A coarse, greyish-white sand taken from pine woods on top of the hill, near the west end of the island. It supports a low, stunted pine tree, here and there, with the intervening spaces covered by moss.

16. Soil from the (Stanton) tract, about two miles south of Toms River, Ocean county. The specimen was taken from a little eminence in the pine barrens and as representing the poorest soil of the tract. It is twenty-four inches thick. A few pine trees on this hill.

17. The subsoil under No. 16. The soil is a white sand, finer grained than the soils 15 and 16. The subsoil is yellow, and also fine grained.

18. Soil 150 yards southeast of the Watering Place, East Plains, Burlington county. A coarse white sand, bare, excepting moss in spots. This white sand layer is one foot thick.

19. The subsoil under the last mentioned, yellow; contains a few quartz pebbles one foot thick. This locality appeared to be the poorest of the East Plains. There are no trees which are over six feet high on these soils. Analyses of two other subsoils from this tract show them to be more promising than this one.

20. Soil from woodland of Dr. Theo. T. Price, half a mile northeast of Tuckerton, Burlington county. Specimen a good average of the soil, which, after scraping off the pine twigs and leaves, is three inches thick. The subsoil is a yellow, sandy loam. Timber is thrifty growth of yellow pine.

21. A natural soil from woodland, side of the Buckshutem road, two miles north of Mauricetown, Cumberland county. A drab colored, sandy loam. Contains some rootlets; free from pebbles; ten inches thick. Timber here is mostly oak, with some pine and some holly. The soil represents the sandy loam soils of this part of Cumberland county. They are easily tilled and respond well to good farming.

22. Soil from Thorofare, Gloucester county. A yellow sandy loam which was taken from a field of sweet potatoes, which rotted badly.

23. Soil from same farm as No. 22, but newly cleared. On this the potatoes were healthy.

The following table shows the pounds of potash, lime and phosphoric acid in several of the soils, analyses of which appear in the table.

The calculation is based upon the estimated weight of an acre of soil six inches deep, a cubic foot of which is assumed to weigh 80 pounds. The weight of soil on an acre is then 1,742,400 pounds; and 1 per cent. of any constituent represents 17,424 pounds; one hundredth of 1 per cent, 174 pounds; and one-tenth, 1,742 pounds, or nearly one ton.

1. Table showing the amount in pounds of Lime, Phosphoric Acid and Potash in various soils, taken on one acre, and six inches deep.

	Classes.	Locality.	Potash, Pounds.	Lime, Pounds.	Phosphoric Acid, Pounds.
1	Gneiss	Flanders, Morris county	1,305	713	3,450
2	Gneiss	Washington, Warren county	2,242	200	2,190
3	Gneiss	Pohatcong Mountain, east of Pleasant Valley, Warren county	3,276	2,069	2,656
4	Magnesian Limestone	Subsoil southeast of Johnsonsburg, on road to Long Bridge, Warren county.	4,180	73,702	5,348
5	Trap Rock	Subsoil, top of Palisades Mountain, near New York line, Bergen county.	2,526	2.438	1,560
6	Trap Rock	Soil, Ten Mile Run Mountain, 2 miles northeast of Kingston, Middlesex Co.	3,310	2,090	1,340
7	Trap Rock	Soil, Rocky Hill, 2 miles north of Princeton, Mercer county	2,258	1,724	2,242
8		Soil, White Oak Bottom road, 3 miles south of Bricksburg	1,380	258	1,448
9		Soil, Geo. W. Cowperthwaite, Toms River	688	361	533
10		Subsoil, under No. 9	783	243	348
11		Soil, on road to Bamber, 1 mile east of Whiting's Station	431	120	431
12		Subsoil, Cedar Bridge road, west of Barnegat	951	71	452
13		Soil, Julius Hincke, Egg Harbor City	627	191	330
14		Soil, 2 miles southeast of Bricksburg	17	29	....
15		Soil, Dillon's Island, Toms River	....	....	....
16		Soil, (Stanton) tract, 2 miles south of Toms River	241	....	310
17		Subsoil, under No. 16	129	310	482
18		Soil, Watering Place, East Plains	609	435	670
19		Subsoil, under No. 13	540	209	783
20		Soil, Dr. Theo. T. Price, Tuckerton	568	207	396
21		Soil, from Mauricetown	690	292	534
22		Soil, (No. 1), Thorofare, Gloucester Co.	1,655	1,829	1,846
23		Soil, (No. 2), Thorofare, Gloucester Co.	2,323	1,916	1,672

2.—Crops and mineral matters taken from an acre of soil in a five years' rotation:

Year.	CROP.	WHOLE CROP. Pounds.	Bushels.	ASH OF CROP. Pounds.	POTASH. Pounds.	LIME. Pounds.	PHOSPHORIC ACID. Pounds.
1	Red clover	4,000		268	92	91	27
2	Red clover	4,000		268	92	91	27
3	Indian corn	3,444	61.5	49	14	2	22
	Corn stalks	4,375		240	85	26	20
				289	99	28	42
4	Irish potatoes	17,920	298.6	400	223	8	50
	Irish potato tops	10,080		180	50	31	14
				580	273	39	64
5	Wheat	1,500	25	25	7	1	11
	Wheat straw	3,000		153	18	9	8
				178	25	10	19
	Total five years' rotation			1,583	581	259	179

3.—Crops and minerals substances taken from an acre of soil in another five years' rotation:

Year.	CROP.	WHOLE CROP. Pounds.	Bushels.	ASH OF CROP. Pounds.	POTASH. Pounds.	LIME. Pounds.	PHOSPHORIC ACID. Pounds.
1	Timothy hay	4,000		280	81	26	30
2	Timothy hay	4,000		280	81	26	30
3	Indian corn,	3,444	61.5	49	14	2	22
	Corn stalks	4,375		240	85	26	20
				289	99	28	42
4	Oats	2,000	66.6	58	10	2	11
	Oat straw	3,332		170	33	14	4
				228	43	16	15
5	Rye	1,400	25	19	5	1	9
	Rye straw	4,200		168	29	15	6
				187	34	16	15
	Total five years' rotation			1,264	338	112	132

The chief constituents of a fertile soil which are liable to be soon exhausted, are, besides organic matter, lime, potash and phosphoric acid. The first table above gives the number of pounds per acre, of these constituents in various soils. The second and third tables show the amount of them taken out by five years' rotations of good crops. An inspection of the first table shows that a very few years of cropping would be sufficient to entirely exhaust some of these soils of their fertilizing constituents if they were all sold off the farm.

In all good farming, however, more or less live stock is kept to consume the coarser and heavier products of the farm, and the animals are sold, while the manure is returned to the soil to enrich it. Much of that taken out of the soil is restored to it again in this way. In the rotation above given, the clover, the cornstalks, the straw and the potato tops are all kept on the farm, and a part of the wheat, potatoes and corn, and the lime, potash and phosphoric acid in them, are restored to the soil in the manure from the stables and the cattle sheds, so that not one-third of that taken out of the soil by the crops is sent off the farm. Skillful farmers will always manage to make the waste from selling the fertilizing elements of their soil, just as little as they can. If good crops taken from the soil would exhaust it in ten or fifteen years,—it can be kept in order three times as long if only one-third is sold off.

To replace the potash taken out from one acre in the five years rotation, would at the lowest present prices of potash cost $40.67, and to replace the phosphoric acid would cost $17.90,—or per acre, nearly $12 a year. The value of land must then depend to a considerable extent on the amount of these constituents naturally in the soils, this value being modified by the condition of the soil and the ease with which it is managed and tilled. In soils from the northern part of the State the amount of these constituents is much greater than it is in those from the southern part. To counterbalance this, however, the cost of cultivating land in the southern part of New Jersey is much less than in the northern, and there is much less loss of time from cold and wet weather.

The principle however must everywhere be admitted and acted on that crops take valuable substances from the soil, and these must be restored in some form, or the capability of the land for

growing crops will be destroyed. Attention to this principle enables farmers on the lighter lands of Southern New Jersey to raise as good crops as are grown in the northern part of the State.

The land needs in addition to barnyard manure, however, other fertilizers to some extent in order to cultivate them to the best advantage. Of fertilizers, those which can be used to the best advantage in most places are muck and greensand marl. Every bushel of marl contains at least 5℔ of potash, and 1½℔ of phosphoric acid, and it can be bought for from 4 to 10 cents, according to the distance from the marl pits. Twenty bushels of marl make a ton, and five tons are enough to supply the whole of the potash and phosphoric acid for the five years rotation,—or a ton a year, which may cost from $1 to $2. It is true the potash and phosphoric acid in the marl are both so combined in it that they do not dissolve in water and so become fertilizing. But under the influence of the vegetable matter in the soils, or of the farm yard manures with which they may be composted they gradually become soluble; and under the influence of muck or of muck and lime they undergo the same change. There is then an abundant supply of potash and phosphoric acid to be had cheaply in greensand marl. An analysis of the average marl is here inserted.

Composition of various marls:

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Phosphoric Acid	1.14	1.33	1.02	2.24	2.69	2.56	3.58	3.87	2.58	2.30
Sulphuric Acid........	0.14	.00	.27	.39	.26	0.22	0.97	0.31	1.89	.00
Silicic Acid and Sand.	38.70	46.03	50.23	50 80	49.40	51.50	53.15	54.75	59.80	57.67
Carbonic Acid.........	6.13	....	....	....	....	....	....	....	....	....
Potash	3.65	5.67	6.32	5.18	6.31	4.62	3.75	4.11	4.25	3.53
Lime	9.07	2.01	1.40	2.13	2.52	1.26	3.27	5.46	2.97	1.26
Magnesia	1.50	3.47	3.45	3.54	3.24	3.95	1.75	2.99	2.00	3.67
Alumina	10.20	7.86	7.94	8.77	8.90	6.01	8.79	6.46	6.00	10.10
Oxide of Iron...........	18.63	25 23	20.14	17.63	17.11	21.04	15.94	15.20	11.98	14.16
Water................	10.00	8.40	9.00	9.66	9.10	7.39	8.98	6.85	8.32	7.25
	99.16	100.00	99.77	100.34	99.53	98.55	100.18	100.00	99.79	99.94

No. 1 is an average of the variety of marl most largely used in eastern Monmouth. It is from the Lower Marl Bed, not par-

ticularly rich in phosphoric acid, but remarkable for containing from 10 to 20 per cent. of carbonate of lime in fine powder.

2. Marl from the Cream Ridge Marl Company, Hornerstown, Monmouth county.

3. Marl from the Pemberton Marl Company's pits, Pemberton, Burlington county.

4. Marl from Kirkwood, Camden county, and from the Middle Marl Bed.

5. Marl from the pits of the West Jersey Marl and Transportation Company, near Barnsboro, Gloucester county.

6. Marl dug at Dickinson's pits, at Woodstown, Salem county.

7. An average of five analyses of Squankum marls from as many different marl banks, near Farmingdale (Squankum), Monmouth county.

8. An average sample taken from a heap of 100 tons sent by the Squankum and Freehold Marl Company to New Brunswick.

9. Marl dug at the pits of the Squankum Marl Company, near Farmingdale.

10. Marl from the pits of the Vincentown Marl Company, near Vincentown, Burlington county. This comes from the green marl layer of the Upper Bed.

The above analyses are, of course, only averages. Single samples from any of them may be found which are much richer, and others which are much poorer. Complaints are frequently made that the marl is not good. Some of these may be well founded, but others are not. Those selling can supply equal to these analyses, and it is their interest to do so. The difficulty may sometimes arise from injudicious use, or from dry seasons. Marl is not a quick, but it is a lasting fertilizer. Its quickest and best effects are seen upon clover and grass.

Muck or black earth is abundant in all the swamps and wet grounds of southern New Jersey. It is vegetable matter partially decayed, and while in the swamp is undergoing no further change. It has then no fertilizing value, but when dug out and exposed to sun, air, moisture and to frost, it soon begins to change and decay. Its change can be hastened by the addition of lime, lime and salt, or barnyard manure. It is then in good condition to apply to the soil. Its office appears to be to improve the texture of the soil, to increase its power of absorbing moisture from the air, to furnish a solvent for the mineral substances in the soil and in mineral fertilizers, and to become the medium of

communication between the soil and the growing crops. It does not contain more potash or phosphoric acid than is found in ordinary soils, and of course can of itself only help to exhaust them quicker, but mixed with marl or other fertilizers in the soil, it increases the crop very largely. Two experiments on a five years' rotation made accurately, at the Agricultural Exhibition Station of the East, at Nancy, France, by Professor Grandeau, upon crops grown in soils fertilized with phosphate of lime, but without muck; and other soils fertilized in the same way, but with muck added, showed that those grown on the soils with muck were 60 per cent. larger than the others, and this result is in accordance with common experience.

Analysis of a Muck from a pine swamp bottom, on lands of George W. Cowperthwaite, Toms River, Ocean county:

Organic matter	77.800
Water	7.950
Matters insoluble in acid	13.800
Alumina	0.174
Oxide of iron	0.250
Lime	0.031
Magnesia	0.216
Potash	0.070
Phosphoric acid	0.026
Carbonic acid	0.008
Chlorine	trace
Sulphuric acid	0.034
	100.359
Nitrogen	1.039

The sample was a good average, and was taken from a ditch bank. The deposit, of which this is representative, has an average depth of about three feet. Deposits of this kind are common throughout Ocean, the eastern part of Burlington, Atlantic, Cumberland and Cape May counties.

With these two fertilizers, both of which require little money, the tillage of these gravelly and sandy loam lands can be begun in an economical way. The first crops upon them will be light, but gradually their fertility will develop, and with good management very satisfactory crops can be produced. The soils are rather deficient in lime, the marl may supply this deficiency, or larger quantities of common slaked lime may be used to profit.

3. MISCELLANEOUS CLAY DEPOSITS.

Clays suitable for yellow ware, Rockingham ware, terra cotta, fire-brick and common red brick are found quite generally distributed throughout the southern and southeastern parts of the State. The openings at nearly all of the localities where they occur, are small, and limited generally to a few small pits, so that the facilities for the examination and study of these clays in their relations to other associated beds have not been such as determine their geological place. The absence of fossil remains, excepting fragments of wood and indistinct leaf impressions at a very few localities, leaves the subject extremely doubtful, and renders their identification difficult and at present uncertain.

There is a great similarity in the general appearance of the white clays, as if all of them belonged to the same bed and had been deposited under like conditions. From this it is probable that they are all of the same geological epoch. But whether that was in the latter part of the Tertiary Age, or was the glacial epoch of the Post-Tertiary it is not possible at present to decide. The great gravel formation of the southern part of the State was deposited during the latter part of the Tertiary epoch. The clays may belong with it, or what seems more probable from their position, in places under the gravel, they may be earlier Tertiary in age.

Some of the clays here described, especially those near the level of tide-water—as the Bridgeton and Maurice river clays—appear to be more recent. The occurrence of beds of fossil oyster shells in and at the top of these clays also indicate their recent origin. It is quite probable that some of these may have been deposited during the Historic Period. Very gradual changes of level would in the course of several thousands of years suffice for their deposition and the re-elevation of the land to its present height.

The localities here described have, with two or three exceptions, been visited and notes as to the extent, thickness, quality and uses of these clays have been collected. There may, possi-

bly, be others of which the Survey has not been informed. And there are, no doubt, many other places at which clays crop out, or may be found near the surface, to which no attention has been directed. Careful surveys and explorations will add to the list of localities and perhaps discover beds of greater extent and of more value.

All of these clays, even the best of them, are quite sandy and do not compare with those of Woodbridge and Amboy in purity and richness. They are all more or less stained by oxide of iron and by thin streaks of yellow earths, and consequently none of them are pure white, but of yellowish or reddish tinge. These impurities do not affect them injuriously for many uses, such as for drain pipe, terra cotta, common fire-brick and yellow and Rockingham wares. Selected lots may do for inferior grades of white ware, or, possibly, for No. 1 fire-brick and glass pot mixtures. At present they are used to a limited extent by the local potteries and other works and supply a home market.

The analyses of the clays are tabulated below. This table shows that all of these clays are quite sandy, and that in all there is a considerable percentage of potash. The oxide of iron, also, is comparatively large in amount. And from these figures there is the proper inference that none of them are very refractory. A comparison of these figures and those of the table on page 72 of the Report on Clays will suggest their trial for making stoneware. The lime and soda were not determined, as these bases are present but to a very small amount. Titanic acid also is present. It was not deemed of importance to be determined. And it is weighed with the alumina. The iron appears as sesqui-oxide.

		Sand and combined Silica.	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Water (combined and hygroscopic)	Total (determined.)
1	White Oak Bottom	72.20	19.20	1.30	....	1.05	6.20	99.95
2	East Plains	71.70	17.70	1.40	0.47	1.90	6.50	99.67
3	Tuckerton	59.40	23.88	3.02	0.69	1.93	10.80	99.72
4	Egg Harbor City	73.70	17.21	1.29	0.39	1.85	5.60	100.04
5	Elmer Earl's	65.10	22 28	1.67	0.68	1.95	8.20	99.88
6	Conrad's	64.00	23.30	1.50	... .	1.77	8.60	99.17

The arrangement of the descriptions of localities is a geographical one, beginning at the northeast, in Ocean county, and proceeding southwestward to Delaware Bay.

BRICKSBURG TRACT.

Clays suitable for red brick have been found at several localities on this tract. A considerable amount has been dug at the pits east of the old Seven Stars tavern, and between Chestnut and Locust streets and River Avenue and Vermont Avenue. The clay is very stiff and tough, and most of it is some shade of yellow or red, although it is said that some of it is white. A gravelly earth four feet thick covers this belt of clay. Selected lots might be used for pipe or for some kinds of pottery.

Two specimens of clay were sent to the laboratory by H. Severance, of Bricksburg, who reported that they came from borings on high ground on the Bricksburg tract, and that the top dirt was eight to ten feet thick, and the clay bed about five feet thick. The specimens were submitted to a fire test. One of them, coarse-grained and white, stood the fire. The other, a pinkish clay, was fused in spots.

BENNETT'S MILLS.

A white, sandy, but quite tenacious clay crops out on lands of Charles H. Appleget, near Bennett's Mills and near a tributary of the Metedeconk creek. The locality was not visited the past season, nor has the extent of the deposit been determined.

HERBERTVILLE CLAY.

This clay locality is half a mile west of the Manasquan river and a mile south of Herbertville, Ocean county. The clay forms the surface—soil and subsoil—in rather low and flat ground. The extension of the deposit is covered by sand in the knolls around it. The clay bed is not over twenty feet above tide-level, and is six feet thick. Under it there is a brown sandstone. The clay is white and sandy. It was used years ago for fire-brick at the Bergen iron works—now Bricksburg. At present it is made into red brick at a small yard, near the pits.

WHITE OAK BOTTOM CLAY.

White Oak Bottom is in Dover township, Ocean county, four miles north of Toms River. The clay bed has been opened on lands of N. C. Whiting, and extends on the adjoining lands of Mrs. H. A. Dunham. The clay forms the surface over a small area, and as opened, the top dirt was soil and subsoil, which were clayey. The top clay is somewhat stained by thin, filmy coatings of reddish-yellow, ochrey earth. The bed has a mean thickness of ten feet. Under it there is a fine, white sand. An analysis of an average specimen of the clay of these pits showed that it contained of

Sand and (combined) silicic acid	72.20
Alumina	19.20
Oxide of iron	1.30
Potash	1.35
Water	6.20
Total	100.25

From these figures it will be seen that the sand makes up quite one-half of the whole mass. In composition it approaches the typical stoneware clays of Amboy, although more sandy than they are. The pits were worked in 1877, and the clay was carted to Toms River, and thence shipped to a pottery firm in Brooklyn. Specimens were sent to Trenton to be tried in white ware. Borings about the pits indicate a considerable extent of clay. It is all above the natural drainage and about forty feet above tide level, so that it can be worked without much trouble or expense from water. As it is only two miles from navigable water at Mosquito Cove, or head waters of Barnegat bay, the transportation also would be comparatively inexpensive. The locality is deserving of further attention and examination.

TOMS RIVER.

Clay for red brick is abundant in the high ground north of this village. And it appears probable that there is a more or less continuous clay bed under all of the high ground between this point and White Oak Bottom, although, as illustrated by these, there may be quite a variation in the material of the bed

from point to point. At Dubuisson's brick yard, one mile north of the village, there is a drab colored clay having an average thickness of thirteen feet and covered by sand and gravel to a depth of four feet. This clay is said to burn light colored and to make smooth, but not very strong, brick. It has not been used excepting at this yard for common, building brick. By careful sorting the best of this clay might answer for drain pipe.

East of the village, on Dillon's Island, and near the Island Heights camp ground, a white and sandy clay appears in the bluff or river bank. The bluff is thirty-five to forty feet high, and the layer of clay is about twenty-five feet above tide level. It is three feet thick. White clays are reported in digging wells on the camp ground, west of the bluff.

(STANTON) TRACT.

On this tract, formerly owned by Amos P. Stanton and later by S. H. Shreve, there has been considerable work done in searching for clays. Ex-sheriff Ivins bored fifteen to twenty-five feet at many points, but did not discover any beds of value, although at one point, a tough, blue clay was found in a bed ten feet thick. Sands and gravels were the prevailing strata, and very thin layers of clay. Some digging and boring made by Mr. Shreve near Sunken Branch, three miles west of Toms River village, opened two layers of yellowish-white clays, each eighteen inches thick and separated by sand. These borings stopped at a depth of ten feet.

LARRABEE'S CLAY PITS.

These pits are a quarter of a mile west of the yard of Larrabee and the New Jersey Southern Railroad, and about a mile north of Whiting's station. The pits are in wet and flat ground near the head of one of the branches of the Union branch of Toms river. There is a gravelly earth and salmon-colored sand on the clay, and this top dirt varies from one to six feet in thickness. The clay is yellowish-white and streaked by a little yellow loam which covers fractures in it. Occasionally a pebble appears in it. The depth of the pits was not ascertained, nor the thickness of the clay bed. The clay was made into building brick at the yard on the railroad. They were of poor quality. Evidently the

clay is too rich in alumina and too hard to burn for such uses. It might do better for admixture with other clay for terra cotta, or stone ware, or, possibly, for fire-brick.

CLAY AT MOUNT MISERY.

Clay was formerly dug near Mount Misery, Burlington county, for making the brick used at the Hanover furnace. The pits are near the old road to Brown's Mills and one mile south of Hanover station. When visited, they were nearly filled up by the sand and earth washed in from the surrounding surface, and the top clay only was seen. That was two feet below the surface and was yellowish-white and sandy. The deeper clay was probably white and of a better quality. The thickness or extent of the deposit could not be ascertained. On the hill a few rods east of the old pits a red clay crops out in the road cut. These pits are about a half mile northwest of the little hamlet known as Mount Misery.

A yellow, sandy brick clay is found a few rods south of the stream and at the settlement. Years ago there was a brick yard here, and red brick were here burned for the buildings at Hanover Furnace.

TOWNSEND'S CLAY, WHEATLAND.

This locality is one and a quarter miles southeast of Wheatland Station, Ocean county. It is on the water shed between the Delaware river and the ocean and according to barometric observations, very near two hundred feet above tidewater level. The pits are at the side of the Wheatland and Cedar Bridge road, and on what is known as the Webb mill tract, and are owned by a company in Toms River. The clay is dug and used by E. N. and J. C. Townsend in their pipe works at Wheatland Station. The strata met with in digging, according to Mr. Townsend, occur in the following order and thickness:

(1) Gravelly earth and clayey sand	7–10 feet.
(2) Black, sandy clay, full of lignite and pyrite	1–4 feet.
(3) Blue, pipe clay	3–8 feet.
(4) Reddish yellow, sandy clay	2–3 feet.
(5) Sandy earth with some clay lumps, (locally called a *kaolin*)	2–3 feet.
(6) Sand with some gravel at the bottom	

The black, sandy clay (No. 2) is a heterogeneous mixture of sand and a chocolate colored astringent earth and contains much lignite in the shape of small sticks, pieces of bark, &c. Leaf impressions also occur in it. It is described in this report, under the head of Miscellaneous Work of the Laboratory, and an analysis of it and some notes about its use as a fertilizer are appended.

The blue, pipe clay is quite sandy. The sand in it is very fine grained. This layer is found to be very uniform throughout all the pits. The reddish clay at the bottom is very thin in places. The clays are carted to the works at Wheatland and used in sewer and drain pipes and in chimney tops. The blue clay mixed with a little of the so-called *kaolin* has been tried in fire-brick. Very little has been done for two or three years past and when visited last season there was a large stock of clay and of pipe also at the works.

The location of the works so far inland and from the larger markets of the country, makes the freights large as compared with localities on tide-water and nearer to large cities and trade centres.

UNION CLAY WORKS.

These works are a few rods east of the Woodmansie and Cedar Bridge road and three miles from the New Jersey Southern Railroad at Woodmansie. They are in Ocean county, but near the Burlington line. The ground is high, being on the divide between the waters which flow eastward to the ocean, and those flowing westerly into the Delaware river. According to barometric observations, the clay bed is 175 to 180 feet above tide-water level. There has been considerable digging and there are three distinct groups of pits. At the pits north of the works there is—

(1) Gravel and yellow, loamy clay	4 to 9 feet.
(2) White clay	10 "
(3) Sand and gravel	4 "
(4) White sand at the bottom.	

East and southeast of the works the digging showed the following section:

(1) Thin covering of reddish, gravelly earth	
(2) Clay of inferior quality	8 feet.
(3) Micaceous clay and sand	4 "
(4) White clay	10 "
(5) Gravel at bottom of the pit.	

The best clay was No. 4 of the latter section. The clay of (2) was not worth much for pipe, except in mixture. These figures do not apply to all the pits as there is some variation from pit to pit. In digging a well at the works, sixty-two feet deep, the strata cut were the following:

(1) Loamy gravel and clay (thin layer.)	
(2) Clay	8 to 10 feet.
(3) Gravel (thin layer.)	
(4) Clay, of good quality	2 to 3 "
(5) White sand	22 "
(6) Sandy gravel at the bottom.	

These figures are from P. H. Lauth and A. L. McCall, who were managers of the works and superintended the digging. They show how the strata vary from point to point and the irregular alternations of clay, sand and gravel.

On the adjoining lands of Daniel Brewer and east of the works the ground is lower and the clay is near the surface. The well at the house, thirty-six feet deep, was dug through the clay.

Borings made about the works for testing the ground show, it is said, a workable clay area, of nearly seventy acres. Of the top clay some is reddish in streaks. It was used in making red brick. The best clay of these pits is white and rather sandy. The works used the materials from the several pits. The best clay was put into drain and sewer pipe. This was mixed with the micaceous sand, which came from below the clay bed. The pipe manufacture was started here in 1866. Previous to that date the clay was tried for fire-brick and common pottery. For the former it was not sufficiently refractory, although the brick were smooth and hard. For pottery it was said to answer very well. These uses were rather of an experimental nature, and the principal business was the making of pipe. It was tried for glass pots, and when mixed with German crucible clay the result was quite satisfactory. The clay looks like some of our

stoneware clays, and it appears to be better adapted to stoneware, or to terra cotta, than to pipe.

The works have been run at intervals and by several firms. They are now idle. There is a considerable stock on hand and some in the kiln unburned. The development of this property began about eighteen years ago, when the first pits were dug. Previous to that time the clay had been known, and the colliers of the neighborhood had been accustomed to use a little of it to chink up their cabins.

SHAMONG.

A bed of yellowish white, sandy clay, four feet thick, was worked several years ago for common, red brick. This clay burned to a cream color. These pits are northeast of the village.

ATSION.

One mile east of Atsion and north of the Atsion river a white, tenacious clay has been discovered, but its extent and thickness have not been ascertained.

EAST PLAINS.

Thin layers of white clay crop out at the Watering Place on Governor's Branch, where the Cedar Bridge road crosses that stream. A little of it has been dug and used by coal burners for their coalings and for chinking up their cabins. A trial pit dug last summer cut through a bed of white clay four feet thick and then struck a brownish sandy earth. The clay which was taken from it is quite white, containing a few thin streaks of yellow earth, and moderately sandy. A partial analysis of the specimens collected at that time gave the following percentages:

Sand and combined silica	71.70
Alumina	17.70
Oxide of iron	1.40
Potash	1.90
Lime	......
Magnesia	0.47
Water (combined and hygroscopic)	6.50
Total (determined)	99.67

The sand (quartz) was not determined but it amounts to 50 per cent. at least of the whole. Such clay might be used for some kinds of pottery. The locality is so far from railroad or boat (seven to ten miles) and the beds, as tested, are so thin that its use does not promise to be at all extensive.

From these outcrops and from those on the West Plains, it seems quite probable that there is a clay formation extending throughout these Plains and the adjoining high lands. According to barometric observation the elevation of this clay at the Watering Place is, approximately, ninety feet, or about seventy-five feet lower than the clay bed as it is opened at the Union Clay Works, which is ten miles to the northwest. These Plains clays may belong to the drift and be of the same age as the great gravel formation of this part of the State.

WARETOWN.

A white, sandy clay occurs at the bottom of a gravel pit a mile southwest of Waretown and a half a mile west of the shore road. It has not been used except as thrown out with the gravel for roads. The locality was not visited. A specimen was received from Samuel Birdsall, of Waretown.

TUCKERTON CLAYS.

White clays have been found at several places within three miles of Tuckerton.

One of these localities is on the farm of Jonathan Nugent, one and a half miles northwest of the village and southwest of Shurd's Mill branch. The clay is found within a foot of the surface in a basin-like depression and about twenty feet above tide-level. Several small trial pits have been dug and the clay has been found seven feet thick. Much water and sand is found at the bottom of the pits, and that is supposed to be the limit of the clay. These pits are all quite near together, so that the extent of the deposit is not known. In the adjoining higher ground it is probably covered more deeply.

The top clay has some thin streaks of yellow, ferruginous earth, which gives it a slightly mottled aspect. That from lower down is not so much streaked. An average specimen representing the deposit was analyzed and found to contain:

Sand and combined silica	59.40
Alumina	23.88
Oxide of iron	3.02
Potash	1.93
Magnesia	0.69
Water (combined and hygroscopic)	10.80
Total (determined)	99.72

The sand (quartz), the soda and the lime were not determined.

A small lot of the best clay of these pits was tested in the pottery at New Brunswick, for stone ware. It did not do well, as it was too hard to burn and too *fat* for stone ware. It appears more like a fire-clay, or it may answer in mixture for terra cotta.

This locality is so near both to railroad and tide-water that it has good facilities in the way of transportation. The labor supply of Tuckerton, and cheap fuel also, make it promising and worthy of the attention of manufacturers.

A clay very like the above is reported on the farm of Eayre Oliphant, about three miles southwest of Tuckerton. Its thickness was not ascertained.

Thin layers of white clay have been met with in wells near the village.

CONRAD CLAY PITS.

The following is taken from the "Report on Clays," 1878:

"These pits are at Conrad, one mile south of Tansborough, Camden county. The Williamstown railroad runs a few rods west of them. The existence of clay here has long been known, and it has been used at times by the people of the neighborhood as a whitewash for out-buildings, fences, &c. About seven years ago the first pits were dug for clay, to make pipe, and about that time works were erected here for the manufacture of pipe, terra cotta and fire brick. The pits go through a bearing of six inches to three feet, and then the bed of clay, five to sixteen feet thick.

"Under this latter there is white and yellow quartz sand. In some places there is a stony layer, from two to four inches thick, consisting of sand cemented together by iron oxide, between the clay and the sand. James Conrad, the former proprietor of the

pits and works, says that this clay can be traced for a mile southeast of his pits; he has found it at several points in borings in that direction.

"This clay varies considerably in its appearance. Generally the best of it is at the bottom, near the stony layer. All of it is sandy, and some of it is mixed with earth in streaks. Its colors are bluish-white, buff and chocolate shades. The chemical composition is expressed by the following analysis of an average specimen:

"Alumina*	23.30	
"Silicic acid	29.50	
"Water (combined)	7.00	
		59.80
"Sand	34.50	
		34.50
"Potash	1.77	
"Soda	0.16	
"Lime	......	
"Magnesia	......	
"Sesqui-oxide of iron	1.50	
"Water (moisture)	1.60	
		5.03
"Total		99.33

*Including titanic acid.

"These figures show that this clay cannot be refractory enough for the best fire brick. They indicate a composition like that of some of our best stoneware clays.

"All of this clay answers for pipe. Some selected lots were used in fire brick, but nothing was learned of their character. For some of the finer and ornamental terra cotta ware the crude clay is washed, sifted and pressed. The ware made of it has a pleasing and soft shade. Some of the statuary looks very well. For the latter, the unwashed, crude clay can be used. The products of the works are shipped over the Williamstown railroad —a side track running to the works. The thickness of the clay, the thin covering of soil, and the location so near the railroad favor this place."

EGG HARBOR CITY CLAYS.

Clays for the manufacture of pottery and for red brick have been dug at several points on the Egg Harbor tract. One of these is Gabler's pit, near Hamburg avenue, and on the west side of the town. A small pit was dug at this locality to a depth of six feet. The clay which was obtained from it was used in a small pottery in the city. There is a thin covering of soil and subsoil on the clay bed. The top spit is gravelly. The lower part of the bed is sandy and the best of the clay contains a considerable proportion of sand. It is white, but reddish-yellow earthy films on the fracture surfaces give it a slight yellowish tinge in the mass. Some of this clay was tried for white ware, but with what result was not learned. A partial analysis gives the following percentages:

Sand and combined silica	73.70
Alumina	17.16
Oxide of iron	1.24
Magnesia	0.39
Potash	1 85
Water (combined) and moisture	5.60
	99.94

Borings made in the flat ground north and northeast of this pit indicate the extension of the bed in those directions.

Clay is reported to occur in the higher ground west and northwest of the Gabler pit.

Another opening for clay is south of the Camden and Atlantic Railroad and a quarter of a mile west of the depot. Several small pits have been dug. There is at the surface a gravelly earth which goes down two to four feet; then the clay bed is struck and that is from ten to twelve feet thick. At the bottom the pits reach a sand bed. The clay is whitish and sandy. It burns cream-colored. Several years ago there was a brick yard near the pits and many brick were made for buildings in the town. A little of it was used at a pottery in flower vases. No clay has been dug for several years past.

These white clays are not so desirable for common brickmaking, as they are not so easily burned, nor do they give the deep red

color so much desired. For some grades of stoneware and for terra cotta they may yet supply a local demand.

Clay for red brick is dug northeast of the town and east of the Catholic Church. It is yellow and loamy and makes a deep, red brick. The clay is covered by a gravelly bed.

A fourth locality where clay is dug, is north of the brick yard and about a quarter of a mile northeast of the brewery. The pit is on a side hill, and the gravelly earth occurs here also, overlying and capping the clay. The latter is buff colored and rather sandy. It has been used in making drain pipe and chimney tops.

East of the town a thick bed of white clay is said to have been discovered in digging deep wells. Beyond the fact of its discovery nothing further could be learned.

These several clays in and about Egg Harbor City appear to be nearly in the same horizon, and all are about fifty feet above tide-level. The white clays look like those found elsewhere in South Jersey, and they are, probably, parts of an extensive formation which overlies the glass-sand bed. The common, brick clays are more nearly related to the great gravel formation, which here constitutes the surface of all the higher parts of the country, and they are of a later age. From these general statements it follows that the list of localities, where such clays may be obtained, can be largely extended by careful searching.

MAYS LANDING.

A white, sandy clay was formerly dug, east of the village and near the Great Egg Harbor river, just south of Babcock creek. The upland bank is about fifteen feet above high tide level. Of this, the upper half is sand and gravelly earth and is eight feet thick. The top clay is white, streaked red and yellow. As the old pits are full of water and top dirt, which has run down into them, the thickness of the clay bed could not be ascertained. No digging has been done here in several years. The clay which was dug was used for drain pipe at a pottery on the river below the village.

The same bed of clay crops out on the west bank of the Watering Place Branch and near the old grist mill site. The locality is a quarter of a mile northeast of the railroad depot. The clay

resembles that seen at the old pits. In digging wells in the village it is found five to six feet below the surface, and is, generally, four feet thick. The wells are seventeen to twenty feet deep.

On the west side of the river and west of the village there is a large, but shallow, pit, where brick clay has been dug. It is at the side of the Weymouth road. The surface layer is a gravelly loam, which is on the average, three feet thick. The clay is bluish-white and sandy. Under it there is a white sand and the bottom of the clay is 5–10 feet above tide level. It is supposed that this clay belongs to the bed, which is found in the wells in the village, and in the river bank east of the village.

At High Bank Landing, one mile south of Mays Landing a clay crops out in the upland bluff, and according to the following section:

(1) Yellow, dune sand	2 to 3 feet.
(2) Yellow sand, with some gravel	12 "
(3) Black clay (to water level)	3 to 4 "

This clay is quite impregnated with *copperas*. In it there are some small quartz pebbles also, but these are sparingly scattered through it. At the water (tide level) there is a stony layer, which may limit the clay. This clay is very tenacious and is adapted to red brick. It is not fit for refractory material or for wares. It is so unlike the Mays Landing clays that it cannot be classed, technologically nor geologically, with them. And yet it occupies the same relative position and is at very nearly the same level. It is more probable that it is of a very recent age, though older than the gravel.

VINELAND.

Clays for the supply of the brick yards are dug at several points on the Vineland tract. At Forest Grove there is a very red clay in a bed which is five feet thick. At pits northeast of the Vineland station a potters' clay has been dug. It is used with Amboy clays in the pottery here.

MAURICE RIVER CLAYS.

Clays have been dug at several points along the Maurice river, between Millville and Buckshutem and Port Elizabeth.

On the west side of the river and one and a half miles from Millville there is the bank of Isaac Mulford. It is at the side of the Buckshutem road and the clay bed appears in the road ditch. The top of the bed is at least thirty feet above tide level. The bank has not been worked in several years and has so caved in as to hinder measurement of its thickness. A careful estimate of Mr. Mulford puts the amount dug at two thousand tons. The larger part of it was shipped to a terra cotta works in Philadelphia. About twenty-five tons were sent to potteries in Trenton. What the results of these trials were was not learned. A specimen of this clay received from Mr. Mulford is white and contains much fine sand. It looks like a good material for stone ware. The bank is so near tide water that it can be put on vessels at small cost or it can be carted to railroad at Millville. Millville offers a convenient location for a pottery that could use these clays of the vicinity and supply in part the home demand. Further exploration and tests of this clay are desirable.

Clay for red brick is dug on the farm of Isaac Hilliard, on the west bank of the river, and three miles below Millville. There is at this bank a very thin covering of loam and top earth. The clay is just above tide-level. It is of a greyish shade of color and is considered a first-rate material for brick. It is carried to the yard of John L. Sharp, at Millville, and there made into common building brick.

A bed of clay similar to the above has been opened on the same side of the river, about a quarter of a mile north of Hilliard's sand dock. The clay from it went to a brick yard.

On the east side of the river and opposite Hilliard's dock, there is the clay bank and brick yard of A. E. Burcham. The vertical section of the bank includes the following:

(1) Sandy loam, with a few scattering pebbles	2 feet.
(2) Bluish-grey clay	10 "
(3) Gravel	3 "

At the bottom there is fine white sand, which is thought to be the glass sand bed. The bottom of the clay is at the level of high tide. The top dirt is used to temper the clay. The bricks made of this clay are of good color, hard and strong.

What is supposed to be the western extension of this clay bed is uncovered at the Hilliard sand pits. These are a quarter of a

mile west of the dock. There the clay bed is five feet thick and lies upon the glass-sand.

The same bed is recognized in the east bank of the river, on the farm of Mrs. Jonathan Lore, near Port Elizabeth. The clay bed is at least seven feet thick and extends down to tide-water. At the top there is a bed of oyster shells two feet thick. As these are of recent age, the clay is most probably more recent than the drift, and, possibly, of the Historic Period. This locality was described and the section figured in the "Geology of New Jersey 1868," *pages 303–304*.

A well dug nine years ago near the Hilliard farm house, discovered a clay bed much like this, and also containing recent shells. The shell-bearing clay was covered by (1) a clayey loam twelve feet thick at the top, then (2) a layer of stone six inches thick. Under it there was the glass-sand bed. The shells obtained from this well were very tender and crumbled on handling. The mass was applied to a spot of ground and its good effects are still visible.

ELMER EARL'S CLAY PITS.

Earl's pits are on his farm, south of his residence, one mile southwest of the Centreton School House, Fairfield township, Cumberland county. They are in rather flat ground, near the head of Cedar creek and about eighty feet above tide-level. The top dirt, or *bearing*, consists of a clay loam and coarse gravel and is one and a half to three feet thick. The bed of clay ranges from five to eleven feet in thickness. Under it there is a coarse gravel and sand. The upper part of the bed is traversed by thin layers of yellow earth. Under this streaked clay there is the white and best clay of the pits. And this is more dense as we get near the bottom of the bed. In all of these there is some sand, but it is fine-grained, which gives compactness and density. The best is selected as a fire clay. The other is sent to potteries. An analysis was made of the best clay of the pits and the following results were obtained:

Sand and combined silica	65.10
Alumina	22.28
Oxide of iron	1.67
Potash	1.95
Magnesia	0.68
Water (combined and hygroscopic)	8.20
Total (of determinations)	99.88

The percentages of oxide of iron and of potash show that the clay cannot be very refractory. These figures agree closely with those of the analyses of the stoneware clays of South Amboy and indicate that they may do well for stoneware.

The original clayey surface of this part of the field led to the discovery of the clay, and the first pits were dug in 1870 and 1871. Since that time several pits have been dug and the clays have been carted to Millville, and most of it shipped to Philadelphia, where it has been used in yellow and Rockingham wares. A little has been used at the rolling mill in Bridgeton, and trials of it in the mixtures for glass pots at the Millville Glass Works are reported. The results of these trials are not definitely known. It has been used in furnace construction. Trials of it for fire-brick are also reported.

In consequence of the flat ground, the drainage is by a long ditch—and this only three feet below the clay surface. The water below that level has to be raised by a steam pump. The pits furthest south show an increasing thickness of the top dirt and a very slight dip of the clay bed towards the south. The ground rises a little in that direction.

The pits are six miles from Millville and four miles from tide-water navigation at Cedarville.

The elevation of this bed of clay and the character of the clay indicate that it is entirely distinct from either the Maurice river, or the Bridgeton brick clays and that it is an older bed, which belongs in the higher grounds only. It is highly probable that it can be found elsewhere, of workable thickness and desirable quality, and careful searches will yet find it at points near transportation and where it can be cheaply worked whenever there is such a demand for these clays as to start exploration.

BRIDGETON CLAYS.

On the farm of B. F. Lupton, a mile and a half south of Bridgeton, and on the west bank of the Cohansey creek, a brick clay is dug and used in Lupton's yard. In its general appearance and in its relations to the glass-sand bed it resembles the Maurice river clays and belongs, apparently, to the same recent formation.

The vertical section of the bank is as follows:

(1) Earth and a little gravel	6 to 7 feet.
(2) Greyish-blue clay	5 to 8 "
(3) Cemented sand	6 inches.
(4) Coarse yellow sand at the bottom	

The sand at the bottom may be the glass-sand bed.

In digging a well a few rods west of the bank there was found:

(1) Loam and gravelly earth	12 feet.
(2) Clay	15 "
(3) "Hardpan"	2 "
(4) Coarse sand	4 "

And the bottom, forty feet deep, was in sand.

At the bank and in the well the clay bed is all above the level of high tide.

CLAY AT FISH HOUSE, CAMDEN COUNTY.

The Fish House clay banks and brick yards are on the Delaware, three miles northeast of Camden. There are two large banks where brick clay is dug and a third opening in the fire-clay bed.

The most northerly of these banks is a quarter of a mile northeast of the railroad station, and on the east side of the track. The ground rises quite rapidly going from the river eastward, and the surface about this opening is forty to fifty feet above tide-water level. The digging has gone down very nearly to that level. This affords a good working face. The surface material to a depth of one to four feet, is a reddish earth and coarse gravel, and included in it there are some cobblestones and small water-worn boulders. Next underlying the top stratum is a reddish-yellow brick earth, which grades downwards into a dark-colored clay, and which appears to be a part of the same bed, weathered and changed in color near the top. The lower, dark-colored clay is sandy and has a laminated structure, and contains some mica in fine spangles. A laminated sand is said to underlie the clay bed. Shells and casts of the genus *Unio*, the fresh-water mussel, have been found in the clay near

the bottom of the bed. These indicate that it is more recent than the plastic clay formation of the State, which belongs in the Cretaceous Age. These banks afford a workable thickness of twenty to forty feet of clays and have natural drainage. They supply material to the brick yards of Hatch & Bro., west of the track and on the river bank. Common and pressed brick are made, and the capacity is said to be 10,000,000 brick a year. Facilities in the working of the bank and the handling of the clays and nearness to markets have made the location a good one, and the aggregate products of the yards have used all the clay from an area of three or four acres.

AUG. REEVES' FIRE-CLAY BANK.

This bank is southeast of the brick-clay bank and about forty rods east of the railroad track. There is considerable variation in the thickness and succession of the strata at the several points of this opening. At the southeast there is loam, sand and gravel over the clay, and in places these have a thickness of twenty feet. These materials are in thin layers, irregularly alternating and varying from loam to fine gravel. The fire-clay under this top dirt, or *bearing* is white, very sandy, and looks like the so-called *kaolin* (micaceous sand) of Middlesex county. Underlying it is a bed of red clay.

Towards the northwest and at the more recently opened part of the bank, the following section was observed:

(1) Very sandy clay (called *kaolin*.)	
(2) Red clay	5 feet.
(3) White fire-clay	3 "
(4) Sand at the bottom of the pits, which is little above tide-level.	

The sand in all of these clays is fine-grained, and there is very little mica in them. The red clay is in part white, and rather mottled. They resemble the clays at Florence and the more sandy clays of Woodbridge and Amboy. The composition of the best fire-clay of this bank is given in the following analysis:

Sand and combined silica	73.35
Alumina	17.26
Titanic acid	1.50
Oxide of iron	1.09
Magnesia	0.20
Potash	0.50
Water (combined and hygroscopic)	6.25
Total	100.15

The presence of titanium in this clay adds to the number of localities where this element occurs and shows its general distribution.

These pits have been worked by Dr. J. S. Hylton under lease which has just expired. The clays went into the market as fire-clays. Hereafter they are to be worked up by the proprietor of the bank at his works, ("Pea Shore Brick and Terra Cotta Works,") on the river, near Fish House Station. The vertical section of this bank corresponds to that of Hylton's banks along the Pensauken creek bluff, in the order of the strata, though these are not so thick and the whole height of the section is much less. It is the same formation and of the Cretaceous age, and, consequently, much older than the brick clays of the neighboring bank. These latter may lie upon and abut against the older fire-clays. Further excavation may show their superposition. They have partially filled the older and broader valley of the Delaware, excavated in the Cretaceous age.

CLAYS NEAR CAMDEN.

Several small pits of clay have been dug near the Mount Holly Railroad junction, and near Baldwin's Run. The *bearing* on the clay is gravel and gravelly earth, the lower part of which is, in places, cemented into a stone-like mass. The excavation of the railroad companies has removed most of this top earth, excepting a stony covering or hardpan, which is two to three feet thick. The top of the clay bed is about three feet below the tracks, and is estimated to be fifteen feet above high water level. It is said to be six or seven feet thick. The clay is mottled, or spotted, red and white, and resembles the spotted clays of the Woodbridge and Raritan river clay banks.

A short distance south of the above described locality sands and some reddish, sandy clays have been dug in shallow excavations made near the line of the railroad. The red, sandy earth and gravel, covering ten to eighteen feet thick, has been removed by the railroad. The clay is in thin layers, and the sand is sharp-grained and somewhat like the Woodbridge *feldspars.* These materials are used in foundries. They are regarded as in the southwest extension of the Cretaceous clay formation.

4. GLASS-SAND.

In the "Geology of New Jersey 1868," *page 690*, the following general statements appeared regarding the glass-sands of the southern part of the State:

"The glass-sand used in the southern part of the State is mostly obtained from a bed which appears to be uniform throughout the whole of that part of the State. It has been represented in the detailed geology as one of the subdivisions of the Tertiary Formation.* It is co-extensive with the Tertiary Formation, and can be seen almost everywhere within the bounds of that geological district, from Shark River to Cape May, and from the outcrop of the upper marl bed to the Atlantic ocean. Near the surface it is not always recognizable on account of the discoloration in it, due to oxide of iron. The remarkable uniformity, or even fineness of the grains, is a characteristic of it everywhere. * * * * * * * * * *

"This sand is generally fine, angular, even-grained and so pure that at many of the glass houses it is used for making window glass without any preparatory washing. But most commonly it is washed to remove the little clay and ashy loam, which may be mixed with it. The sand should be free from all gravel, although it is best if quite coarse. The more angular the grains the better. Smooth, rounded grains, or sand, which is very fine, cannot be used without much difficulty on account of its settling in the *batch*, and so preventing an even mixture with the flux. Clay and loam can be washed out, though the best sand is that in which the grains are clear and white."

In the course of the field work of the past season nearly all of the localities were revisited and notes as to their deposits collected. It has b· en thought best to use these notes for this report, and they have been arranged and supplemented by a few notes of previous years, so as to present a general review of the whole

*It is most probably, Pliocene, being newer than the Shiloh marls which are Miocene and older than the gravel.

field, together with such details as have seemed necessary to make it instructive and plain to all seeking information in this direction. It will, therefore, be understood that this is only a preliminary report, introductory to a more full and systematic one to follow this another year. It is hoped that a more detailed survey of Southern New Jersey will discover the geological position of these several outcrops and indicate their relation to one another, as well as to other associated beds. At present they appear as parts of one thick bed, which dips very gently towards the southeast and whose outcrops form the greater part of the belts of pine lands. At some of these localities the bed is at the surface and hence the pits are shallow,—mere trenches and holes. In others, as along the Maurice river and also near the Cohansey, it is covered by clay beds of recent age. The arrangement of the descriptions of localities is geographical.

LEBANON GLASS WORKS.

Sand for these works is said to have been obtained near them.

TAUNTON GLASS-SAND.

This locality is a little over a mile north of Taunton and within a few rods of the Medford road. The sand forms a thin, surface bed, or layer, on gently rising knolls. Shallow pits have been dug here and there, over an area of several acres. In consequence of this sandy surface the growth of wood is limited to scattered yellow pine. In digging, the turfy layer, about six inches thick, is removed. The sand has an average depth of one to two feet and lies upon a yellow, loamy sand. The glass-sand is white, and the grains quite angular and irregular in shape as well as of varying sizes. Occasionally there is a little earth in it and yellow quartz grains. These are removed by washing. The washed sand is carted to the works of Yarnall & Trimble, at Medford, three miles distant, where it is made into hollow ware.

TUCKERTON GLASS-SAND.

The glass-sand bed has been uncovered in a gravel pit on lands of Dr. Theo. T. Price, a few rods west of the railroad and one mile north of Tuckerton. There is at this place:

(1)	Gravelly loam	4 feet.
(2)	Glass-sand	7 "
(3)	Sand and gravel at bottom	

The bed of gravelly loam is dug for road-making material. The sand is white, uniform in size of grain and contains but little loam, in a few thin streaks. The bed has not been worked. The surface of the ground is about twenty-five feet above tide-level, and the sand bed is, therefore, about fourteen to twenty-one feet high. As it is not wet and is so near navigable water, and has cheap labor at hand, it would seem to be a locality which should command attention from parties who may be looking for new deposits of sand for glass-making.

EGG HARBOR CITY.

In some of the wells dug in Egg Harbor City, and at the clay pits, a bed of sand has been struck at seven to twelve feet below the surface. Some of it would answer for glass-making.

ABSECON GLASS-SAND.

The glass-sand bed was uncovered southeast of the village of Absecon, in the cut of the Camden and Atlantic Railroad. The vertical section in this cut is as follows:

(1)	Soil and yellow, gravelly loam	2 to 3 feet
(2)	Gravel, in layers alternating irregularly with sand	8 "
(3)	Bed of glass-sand (to bottom of cut)	4 to 10 "

The sand in the gravel is marked by lines of false bedding, and the gravel by many fossiliferous pebbles. The thickness of the glass-sand is not known as the cut does not get through it. Practical glass-blowers have pronounced this sand to be of remarkably good quality. It has not been tried. It is near both railroad and navigable water, and can be worked easily as it is above the water level and the natural drainage.

MAYS LANDING GLASS-SAND PITS.

Glass-sand has been dug at several places south of Mays Landing and near the Estellville road. The first of these, going from

Mays Landing, is on the east of the road and a quarter of a mile from the village. The surface is very gently mamillated, in low, flattened knolls; and it is almost clean white sand. The pits are two to three feet deep. At the bottom a yellow sand is found.

Further on, and at the township line, some digging has been done on the west of the road and a few rods only from it. The sand at this place is much like that nearer the village, excepting that the bed appears to be thinner—from one to two feet thick.

The next locality is west of High Bank Landing, and one and a half miles from Mays Landing. It is east of the Estellville road. The white sand knolls hereabouts look somewhat like the dunes of the shore beaches. And there are two, if not more, lines of these hillocks. One of them is close along the river and the second is 300 yards west of the first and parallel to it. In both of them many holes have been dug and sand taken out for the works at Estellville. The thickness of the white sand varies from one to three feet. It is underlaid by yellow sand. The grains appear quite uniform in size and more rounded than those of the Maurice river and South Vineland sands. All of these localities are alike in the superficial nature of the bed and its comparative thinness. It constitutes the surface formation. And it is quite probable that the knolls, or hillocks, are dunes heaped up by the wind, and that the white sand and the underlying yellow sand are one and the same bed, the top of which has been bleached in some way by agents acting on the surface.

THOMAS RICHARDS' SAND PITS, JACKSON.

Richards' glass-sand pits are one mile west of Jackson and one mile north-northeast of Atco, and near the Berlin and Jackson road. The vertical section, as observed on a former visit, is as follows:

(1) Yellow, gravelly loam and irregular, alternating layers of white sand, varying from	5 to 8 feet.
(2) Glass-sand (average).	5 "
(3) Sandy earth—at bottom.	

The above section was obtained from the southernmost pits. The older diggings were nearer the road. In the sand bed there

are layers, from half an inch to six inches thick, of reddish-yellow, sandy earth. This earth is removed in the digging and separated carefully from the sand. The sand is white and rather fine-grained, and is used at Richards' works at Jackson for window glass.

WATERFORD.

Glass-sand for the supply of the works at this place is obtained from pits near a small stream west of the place.

HAMMONTON.

Glass-sand was formerly dug on a small farm at the head of the Hammonton lake. This locality was worked for the glass-house at Hammonton and for those at Waterford and Winslow, previous to the discoveries of sand deposits at these places.

WINSLOW GLASS-SAND.

Sand for the glass works of A. K. Hay & Co., at Winslow, is dug near them and in the village. The top dirt is sandy loam soil with some gravel and yellow, sandy earth and coarse gravel varying from two to five feet in thickness. The sand bed is said to be six to seven feet thick. This sand is yellowish and fine-grained. Near the top of the bed there are some thin layers of loam. The whole bed is dug together. It is clean enough for common hollow ware, and is not washed.

WILLIAMSTOWN GLASS-SAND.

In the vicinity of Williamstown there are several localities of glass-sand and extensive pits. They supply the works at Williamstown, Glassboro, Clayton and Malaga.

J. A. SICKLER'S PITS.

These pits are about one mile northeast of Williamstown, at the side of the Sicklertown road and south of Four Mile Branch. The bearing on the sand averages three to five feet, but is as much as seven feet thick in places. It is reddish-yellow, gravelly earth, with some sandy loam. The sand is washed and sifted,

and it is very white and even grained. It is sold, in the ground, to the works at Malaga, Glassboro and Clayton, to which points it is carted in wagons.

PITS OF HURF & BRO.

These are three-quarters of a mile north-northeast of Williamstown and near a small tributary of the Four Mile Branch. The top dirt, or *bearing*, varies in thickness up to a maximum of ten feet. But the average is four to five feet. The sand bed also varies from a maximum thickness of ten feet and averages about six feet. Under it, next the sand there is a yellow, sandy clay, and under that alternating, thin layers of sand and clay, in which there is a great deal of water. Water and quicksand hinder deeper digging. The glass-sand has some loam in it, in places, and generally it is coarser grained near the bottom of the bed. Some of it could be used without washing, as it is almost pure quartz. But it is all washed by water of the brook near the pits. This flowing over sieves carries away the earth and removes the coarser grains and any pebbles which may get into it in digging. The sand is sold in the ground, or washed and delivered at the glass works. It goes to Williamstown, Clayton and Glassboro. These pits have been opened and worked about forty years, and they have yielded many thousands of tons of glass-sand. Several acres have been dug over.

CHAS. H. STEWART'S PITS

Are not more than a quarter of a mile west of those of Hurf & Bro. The general character of the sand, as to its stratigraphical relations, is very similar to those given above in the description of the pits of Hurf & Bro. North, northwest of Stewart's pits glass sand has been dug on lands of S. Jennings and others. The localities have not been visited. According to report the amounts dug are comparatively small.

ARTHUR DOWNER'S GLASS SAND.

A specimen of glass sand has been received from Arthur Downer, Monroe township, Gloucester county. The locality is west of Williamstown and near Scotland Run. The top dirt is

reported by Mr. Downer to be clayey gravel and dirtv sand and on an average eleven feet thick. The sand bed is also eleven feet thick. The specimen was taken from a depth of sixteen feet. It is white and fine-grained, and looks like good material for glass.

VINELAND.

Some of the wells in the town are said to get through the gravelly loam bed and to reach the glass sand. West of the town this surface formation is wanting and the sand forms the soil and subsoil. And sand for glass-making has been dug near Landis avenue and on the east of Maurice river. The sand is at the surface and the pits are only a few feet deep.

SOUTH VINELAND GLASS-SAND PITS.

These pits are south of Butler avenue and a few rods east of the Millville road, on Main avenue and on the lands of Speer Brothers and of Osborn Bidwell. The surface here is gently rolling and about eighty feet above tide-level. The vertical section at the more northern diggings is as follows:

(1) Soil and reddi-h clay gravel	4 feet.
(2) Red sand (used as moulding sand) wanting in places	3 "
(3) Glass sand	8 to 10 "
(4) *Hardpan*—reddish, cemented sand (in places)	4 "
(5) Glass-sand.	

Towards the southeast the bearing on the sand is thicker, up to 10 feet. The thickness of the lower sand is unknown. The well at the pits is forty-two feet deep, and that did not get through the glass-sand bed. Near the top of the bed the sand is mixed with some thin loam layers. These are between one-sixteenth and one-quarter inches thick, and appear, in general, horizontal in the sand. They are not seen in the lower part of the bed. The sand of these pits is rather finer-grained than that of the Maurice river banks, and it is very clean and white—nearly pure quartz. Much of it is clean enough without washing, but all of it is washed at the pits.

These pits have been worked many years for the supply of the works of Whitall, Tatum & Co., at Millville. The sand is carted

thither by teams. As the distance is three miles only and the road a gravel turnpike, the expense of hauling cannot be large.

MILLVILLE, PETTICOAT RUN SAND.

A little sand has been dug at the pits east of Millville, near the Manumuskin road, and also near the Petticoat run, a branch of the Maurice river. The pits are not deep as the sand is at the surface. The sand is washed at the brook and taken to the works in Millville.

BRONSON'S SAND PITS.

These are on the east of the Port Elizabeth road, and a mile and a half south of Millville. The sand is the surface bed and is covered by the thin layer of turf. It is two to three feet thick and rests upon a dark-colored sand. The grains are somewhat rounded and of varying sizes. Localities, as this, having little, or no top dirt to be removed, are worked cheaply, and their number can be greatly increased.

SAMUEL HILLIARD'S SAND PITS.

These pits are four miles south of Millville and between the Buckshutem creek and the Buckshutem road. The present working is in the upland level, which is at least twenty-five feet above tide-level. At the northern end of the opening, or bank, the vertical section consists of the following beds:

(1) Sandy loam soil and subsoil, containing some gravel	2½ to 3 feet.
(2) Clay, greyish-white, with reddish streaks	4 to 5 "
(3) Yellow sand and fine gravel	1 foot.
(4) Glass-sand (to bottom of pits)	12 to 16 feet.

There is so much water when the bottom is reached that the work stops there, although the sand runs deeper.

In the southernmost pits

The Clay No. (2) is	2 to 3 feet.
(3) Yellow sand and gravel	2 "
(4) Glass-sand, to bottom of pits	8 "

The clay immediately over the glass sand would do for red brick, but as it is needed to fill the pits, it is thrown with the other top-dirt, back into them. The sand bed exhibits very finely oblique lamination in its structure. Its uniform thickness is quite remarkable. The sand varies in purity according to the size and number of the loamy sand streaks in it. These occur as spheroidal, lenticular and irregular shaped masses in the clean white sand. The separation of these is not practicable while digging, and, consequently, all of the sand is washed. It is carted to the washing works, at the dock on the river bank, about a quarter of a mile east of the pits. The water for washing is pumped out of the river. Sifted and washed it is loaded on vessels and shipped to the desired points. These works can clean about forty tons a day.

These pits were opened in 1842 by Anthony Sharp. They were worked for many years so as to supply 1,000 to 2,000 tons a year, and about an acre of land was dug over. Hilliard's digging has been more towards the north, and a large area has been worked out. The product is said to amount to 10,000 to 12,000 tons annually. It goes to glass works in New England, New York, Brooklyn, Jersey City, Philadelphia and elsewhere. The supply appears to be very large, and the location is so convenlent for cheap transportation that this sand can be furnished in quantity large enough to meet all demands, and at low prices.

Glass-sand was formerly dug on the *Taylor farm*, three miles south of Millville and about one mile north of Hilliard's bank. The bank was a few rods west of the river. The *stripping*, or top dirt, at this place varied from ten to seventeen feet in thickness, and consisted of yellow, loamy sand with thin layers of gravel and gravelly clay. The sand was worked to a depth of sixteen to seventeen feet, down to the water. Portions of the bed contained some loam which gave it a reddish color. But the greater thickness consisted of almost pure quartz sand. And the lower part of the sand, as here dug, was considered the best. The sand was all washed previous to loading. This bank was largely worked for several years. And the sales in a single year amounted to 5,000 tons. Of late years the sand business on the Maurice river has been transferred from the old Sharp farm to Hilliard's bank.

THE HOLLINGSHEAD SAND BANK.

Was also worked extensively. It was south of the Taylor bank. The product of this bank along the river in 1867 was estimated at 10,000 tons by persons thoroughly conversant with the business. Then there were three banks worked, now there is one only.

RAMMEL'S MILLS GLASS-SAND.

Glass-sand occurs near the Cohansey creek, at Rammel's Mills, four miles north of Bridgeton. The supply of sand for the Bridgeton glass houses for one year came from this locality. The sand was found under a *bearing* fifteen feet thick.

B. F. LUPTON'S GLASS-SAND BANK.

This locality is one and a half miles south of Bridgeton and on the west of the Cohansey creek. The top of the bank, or upland bluff, is about thirty feet above the level of high tide. There is at the top earth and gravel three to six feet thick, then the bed of glass-sand, which is eighteen feet thick. Near the top of this bed there are thin layers of yellow loam in the sand. Lower these diminish and the sand is almost pure quartz, and it is finer grained. Under the glass-sand there is a coarse grained yellow sand. As the bank is only two hundred yards from the navigable water of the Cohansey, it is conveniently located for shipment. It was opened about twelve years ago. But comparatively small amount has been dug, and nearly all of it has been used in the Bridgeton glass houses. Mr. Lupton is about starting glass works near the bank and he intends to use his sand altogether, instead of selling as heretofore. But there is no reason for any reduction in sales where a locality has such advantages.

BARRENS GLASS-SAND.

This locality is in Salem county, west of Shiloh and south of the Bridgeton and Salem turnpike. The district is known as the Barrens on account of its white sand soil and its poverty as compared with the rich farming lands on each side of it. The

diggings are shallow pits which are not over four feet deep. After removing the turfy surface layer the sand is found and it is from two to three and a half feet thick. Under it there is a yellow sand. A small stream furnishes both the power and the water for washing the sand. It is carted to the Quinton and Salem glass works.

5. UNITED STATES COAST SURVEY TRIANGULATION IN NEW JERSEY.

The coast survey work of determining the exact latitudes and longitudes of conspicuous and well marked points in different parts of the State has been continued during the year under the charge of Prof. Edward A. Bowser. The importance of this work, in preparing an accurate basis for all our general and topographical maps cannot be over estimated, and it finds immediate use in the maps of the State Geological Survey. The expenses of this survey are paid by the general government, and the results obtained are part of the data for the Geodetic Survey of the whole United States. The order in which the surveys in New Jersey shall first be prosecuted is somewhat under the control of the State Geologist, and is intended to suit the progress of the geological surveys. It is of much importance for our work to have the United States Geodetic work continued steadily every year.

The following report on the triangulation work for the past year was prepared by Prof. Bowser:

"REPORT ON THE PROGRESS OF THE GEODETIC SURVEY OF NEW JERSEY.

"NEW BRUNSWICK, December 7, 1878.

"Four primary stations have been occupied and completed, viz., Mt. Rose, Newtown, Goat Hill and Pickles. The fifth station, Mt. Horeb, is about half completed.

"Ten tertiary points have been observed upon from two primary stations and their latitudes and longitudes computed. Fourteen other tertiary points have been observed upon from one primary station. As soon as they are observed upon from a second, their positions will be computed.

"Several of the tertiary points are marked with stone posts; in addition to this the position of each station is secured by measurements and magnetic bearings from the centre of the station to large rocks, trees, or stumps; also a written description and topographical plan of the ground, its surroundings, &c., is made. When the signal observed upon is a church steeple, no marks have been made. It would be well in this case to secure the position of the station against accident from fire or whatever else might destroy the building, by measurements and magnetic bearings to rocks, stumps, &c., as in the former case where stone posts are put to mark the centre of the station; and when there are no natural reference marks, posts about three (3) feet long and six (6) inches square of the most durable stone should be set leaving about four (4) inches out of the ground.

"E. A. Bowser."

6. TOPOGRAPHICAL SURVEY OF THE COUNTRY BETWEEN WATCHUNG MOUNTAINS (KNOWN AS ORANGE MOUNTAINS) AND THE HUDSON RIVER.

The outlines of this work were given in last year's report. The survey covers the whole country which is bounded on the north by an east and west line drawn through the northerly curve of the Passaic river north of Paterson; on the east by the Hudson river, New York bay and Staten Island sound; on the south by Raritan river, and west by First Mountain. It comprises an area of 408 square miles, and nearly half the population of the State is on it. Improvements in drainage, water-supply, road making, and everything tending to provide for a dense population, are in progress within it. Elaborate topographical maps are essential for carrying on these works judiciously and economically. And they are absolutely necessary for strictly geological purposes, to locate and define the outlines of soils, and rock outcrops, and to show where deposits of clay, sand and gravel are to be found, and where quarries for building stone, road material, or other purposes may be properly looked for.

This survey will be completed in a few days—less than a week's field work was to be done when the cold weather came on. The principal work has been in leveling, which has been done with the engineer's level. Every hill and even knoll in the whole district has been surveyed and its height above tide-water determined.

The map will be drawn as fast as possible, but it will take some months to finish it. The northern half is well advanced, however, and it will be ready for inspection by the middle of January. It is on a scale of three inches to a mile, and the contour lines or lines of level, are drawn on it for every twenty feet of elevation, and in some cases every ten feet.

7. PROGRESS OF THE DRAINAGE WORKS.

The plan for the drainage of the Great Meadows, on the Pequest river, in Warren county, has been carried out; the work is mainly done, and is a complete success. The need for the drainage of these meadows was reported to this Board at the annual meeting in 1870, and a survey and plan for the accomplishment of the work was given at the same time. The report was accepted and approved at that time, and the proper steps taken for placing the execution of the plan in the hands of commissioners, as required by the general law "To provide for the drainage of lands." The commissioners and their engineer have been engaged in preparing for the work, and in carrying it out till the present time. The difficulties from opposition, delays and hard times have been vexatious and embarrassing, and nothing but the consciousness that they were doing a great and useful public work could have enabled them to go on with the perseverance and enthusiasm which they have shown.

Their work is in the highest degree successful. On the 19th a committee of this Board visited the Great Meadows and walked along the deepened channel for five or six miles. The water in the stream, notwithstanding the recent and very heavy rains did not more than half fill the channel, and the swamps on either side were quite dry. These swamps were formerly inaccessible, except when frozen in winter. Now they can be reached at any time, and the valuable timber in them can be marketed at a reasonable cost. As soon as the lands are cleared they can be put in pasture or meadow, or can be tilled—and experience everywhere else has shown that such drained lands are worth much more than good upland.

The advantages of the drainage were well shown when, at our late visit, we came in sight of the flat lands on the Pequest above where the channel is cleared. The whole flat land was covered with water and must remain so some time longer, or perhaps all the season. The following is the engineer's report of the work:

"VIENNA, WARREN COUNTY, NEW JERSEY,
"December 17th, 1878.

"DEAR SIRS:—I submit the following history and description of the drainage operations on the Great Meadows, along the Pequest river in this county, up to date.

"Under the general act of 1871, seventeen (17) landowners on these Meadows made petition to the Board of Managers of the Geological Survey, asking for the drainage of the Great Meadows by public authority. The Board of Managers directed the State Geologist to examine and report. Thereupon the Managers laid their plans before the Supreme Court, and recommended the appointment of commissioners for the execution of the work. After the usual legal notice given, by handbill and newspaper advertisments, calling for objections to the plan proposed, and appointment of commissioners, and no objections being made, the Supreme Court appointed three commissioners, not owners, and wholly disinterested, as required by law, in November, 1872, and put in their hands the profiles, maps and descriptions of the drainage proposed, and they were duly sworn to the faithful performance of the work in January, 1873.

"The tract to be drained is described in the appointment as 'situate on both sides of the Pequest river, from Vienna to Danville, at the westerly end, to a point in Green township, Sussex county, about one-eighth of a mile from the line between the counties of Sussex and Warren, and embracing an area of drowned and wet lands of five thousand seven hundred and fifty-six (5,756) acres. The boundary of said tract is plainly marked upon the surface at the meeting of the flat and boggy meadow or swamp with the upland.'

"The said system or plan of drainage is to cut a channel thirty (30) feet wide, and lower the reef at Vienna bridge three and a half (3½) feet, at Steam Mill bridge, five and a half (5½) feet, and at Long bridge, three (3) feet, reducing the bottom between these points to the grade line represented on the profile, and to make the work complete, the streams through the Great Meadows must be cleared of obstructions and given capacity enough to carry the streams within their banks.

"The work was commenced and prosecuted in the summer and autumn of 1873, and has been continued since, as rapidly

as the season, the character of the work, and the means in hand would allow. The work now accomplished to this date is as follows:

"The main channel of Pequest river is cleared and opened complete, for a distance of nine and three-quarter (9¾) miles, being widened to thirty (30) feet, five and a half (5½) miles; to twenty-seven (27) feet, one (1) mile; and to twenty-four (24) feet, three and a quarter (3¼) miles.

"The bottom of the river has been graded to a uniform surface, with a fall of one (1) foot to the mile, for four (4) miles; to two (2) feet per mile, for a distance of one (1) mile; three (3) feet per mile, for two (2) miles, and one and a half (1½) feet per mile for two and three-quarter (2¾) miles.

"The excavation has averaged about three and a half (3½) feet in depth, for the whole length of channel, being at or near grade, about five (5) per cent. of the whole distance, and ninety-five (95) per cent. in depths varying down to eight (8) feet, this last being on the sides of the natural channel, and is now the depth of the river bottom, below the general surface of the meadows.

"The bottom of the stream nearly throughout, is hard and cohesive, very little being miry or soft. The work has been almost wholly among solid material, some boulder rock and hardpan, but no ledge rock, although the newly excavated channel, appears now in several places, to be close upon the bed rock of the valley. Through the Great Meadows proper, a distance of six and a half miles, the channel was found to be through a sandy clay, so close and dense as to task, to its full capacity, the dredge machinery, driven by a forty-horse power steam engine.

"The amount of excavated material in the whole nine and three-quarter miles, is one hundred and eighty-two thousand (182,000) cubic yards. Much other work, besides the excavation, has also been necessary, to make the drainage abiding and successful. The outlet proper was first opened for the spring freshets of 1877, and then and since, the action of the stream, upon its new banks and bottom, both at high and low water, dissipates all apprehension as to the enduring character of the work, and its beneficial results.

"The heavy rain-fall of the 9th and 10th inst. (said to have been the greatest since 1841), did not bring the river up to its former high water mark, by three feet nine inches, and, contrary

to all former precedent, the water began to fall almost immediately upon the cessation of the storm, heretofore continuing to rise for several days thereafter. Actual observations at different stages of water show the current to be from 100 to 220 feet per minute. Any bars or deposits formed under high water are taken away, as the stream settles again to its ordinary size and channel, and all indications are that the stream will keep for itself a clear and open channel.

"The other 'streams' on the Great Meadows, tributary to the Pequest, and required by the 'Plan' to be cleared and opened, are Hoagland's mill brook, Stinson's brook, Smoke's mill brook, and Trout brook from Allamuchy pond. Heretofore the water from the streams have spread over the meadows for want of a fall and a channel. Channels have now been cleared and excavated for them, so as to carry the water directly off, for an aggregate distance of five and a quarter (5¼) miles, with excavations averaging three and a half (3½) feet in depth, and amounting to nine thousand two hundred (9,200) cubic yards.

"The lands relieved of water two years ago, by this drainage, are, to some exent, being already put under cultivation, and most satisfactory crops of corn, potatoes, oats and especially of corn fodder, have been reaped the present season from lands standing under water in August, 1875. Preparations for an increased area of culture of these lands next year, are now progressing. Over two and a half (2½) miles of private ditches have already been opened into the main outlets.

"The cost of the enterprise so far, has been kept within the estimates originally made, and its friends see no hindrance to the complete success of the work, unless it be litigation. The expense of the whole has been increased very considerably by this litigation, and has added much to the labors and cares of the commissioners appointed by the supreme court to superintend the work, and who, in every step taken, have only endeavored to perform their *sworn* duty according to law.

"The undertaking has been entered upon, with the facts and figures all before, or accessible to the landholders. It was by law, made wholly within the control of a majority of the ownership, whether to begin, to stop, or to go on. Once commenced, and thus far so successfully prosecuted,—benefits to some extent already realized,—and third parties, in the shape of

bondholders, contractors, and other innocent and outside parties involved, there should now be no hesitation or waver in sustaining so beneficent a work, to the full completion.

"The commissioners appointed by the Supreme Court to execute this drainage are

"Amos Hoagland, Townsbury, Warren county;

"James Boyd, Vienna, Warren county;

"Wm. L. Johnson, Hackettstown, Warren county.

"Respectfully yours,

"ABM. R. DAY,

"*Engineer.*"

The lands on the Passaic river and its branches, the Whippany and Rockaway rivers, above Little Falls are subject to overflow in times of freshet. There are more than 11,000 acres of these flowed lands, which cannot now be used for any purpose except meadow and poor pasturage. A heavy rain at any time in July or August is sufficient to flood these meadows, to spoil the grass, and leave the water to stagnate on the surface and become the fruitful source of malarial disorders of all kinds, and to bring not only the lands themselves, but a much larger area of the surrounding country into discredit, and make its lands unsaleable. The tract of country thus damaged is one of the most beautiful, and but for this insufficient drainage one of the most desirable portions of the State. The primary cause of the defective drainage, is a reef of rocks across the stream at Little Falls, and a bar of boulder earth across the Passaic at Two Bridges just above the mouth of the Pompton river. There is also a dam across the river at Little Falls, which has been made to *improve* the water power there. This dam is about a foot and a half higher than either the reef or the bar.

Attempts for the removal of these obstructions, have been made at various times for the last hundred years, and legislative action was had in regard to it in 1788. In 1790 an act was passed "to enable the owners and possessors of the meadows, swamps and low lands on the river Passaic and its several branches between the Little Falls and the mill dam at Chatham to break up the reefs near said falls and to dig canals for the more effectual drainage of said lands and to raise money for that purpose." And in 1812 this act was reiterated as far as breaking

up the reef was concerned. In 1815 an act was passed repealing that part of the law of 1812 which authorized the assessment of the lands flowed for the expenses of breaking up the reef. Several acts for clearing the river have been since passed, but nothing effectual has been done, and since the completion of the stone dam a few years ago the obstruction to the flow of water and drainage of the land is worse than it ever was before that time.

From the bed of the river at Lower Chatham to the top of the dam at Little Falls, a distance of twenty-one and three-quarter miles, there is a fall of only six and three-tenths feet, or less than three and a half inches per mile. The dam can be lowered seven feet, and the bar and reef cut down to the same level with the lowered dam without much other work, as the bed of the stream everywhere else is now deep enough. When this is done, the stream from Chatham to Little Falls will have a fall of thirteen and three-tenths feet, or about seven and a half inches per mile, which would give the current a velocity of from ninety to one hundred and twenty feet per second, and enable all the water of the stream to run within the banks, and prevent overflow.

This work was reported on to this Board in 1869, and in 1871 on the petition of land owners, commissioners were appointed, under the general drainage law, to do the work. The difficulty of raising money to pay the mill owners' damages, before they begin to clear out the obstructions, has prevented the beginning of the work up to this time.

It is greatly to be desired that this drainage should be done. It would bring a large area of excellent land into profitable use, and thus increase the wealth of the State. It would be a public benefit in removing a fruitful source of disease. The damage done by the overflow this year is nearly, if not quite enough, to pay the cost of removing the obstructions. And the lands drained, which are liable to be assessed to pay the expenses, are worth far more than the assessments would amount to. If townships, counties, or State could endorse the improvement bonds, so that money could be raised, the work could go on immediately, and the bonds be paid, gradually by the proceeds from taxes on the lands benefited.

8. WATER SUPPLY.

The question of water supply is growing in interest every year. Many applications come to the office of the Survey for information regarding the quality of different waters, the probabilities of getting water by artesian wells, &c. All these questions are of interest to the persons inquiring and some are of public importance.

The State Reform School for Boys, at Jamesburg, has heretofore obtained all its supply of water from wells and springs on the grounds and not far from the dwellings. The past summer a large number of the boys have been sick from fever or other disorders, and two or three died. There was much alarm at the sickness, and after thorough examination, the cause was traced to impure drinking water. The buildings are located on a knoll or low hill. The top earth of this knoll is open, gravelly sand and loam for from twelve to fifteen feet down. Underneath this is a very solid black clay, nearly flat on the upper surface but sloping to the southeast. All the water here comes from the rain, which falling on this gravelly soil, sinks in it till it reaches the clay, when it soaks off towards the southeast outcrop of the clay, where it appears in the form of springs. The water of these springs has been collected into two large reservoirs, and from these the principal supply is drawn. A few wells have been sunk down to and a little in the clay, but the water is of the same character and comes in the same way, from the drainage through the gravel and surface earth. Water collected in this way where a large number of persons are living together is always liable to dangerous contamination. In this case the supply was abandoned and water for drinking brought from a distance.

The geological materials at the school are alternating beds of clay and sand, and good water is usually found in the sand, though it sometimes contains a little sulphate of iron or copperas. It is probable that a bed of sand sufficiently thick and open to

carry a good supply of water will be met at not much over a hundred feet from the surface; and as the clay effectually shuts out all surface water from those lower layers of sand, the water will be free from surface filth or any organic impurities.

The plan proposed is to bore an eight-inch well, and the work is in progress.

At the State Prison in Trenton a large amount of water is needed, and a well has been dug to help out their supply.

The prison is located on flat ground not far from the Delaware and south of the city. The surface of the ground is forty-five feet above low water in the river. The material on the surface is a modified drift, consisting of boulders, cobblestones, gravel, sand and loam mixed, but it was presumed that the granitic rock of the vicinity would be found at the depth of thirty or forty feet. The well was dug of a clear inside diameter of twelve feet eight inches, besides the brick lining, nine inches thick, and the heavy plank curb outside the bricks.

The materials passed through were—

(1) Gravel, &c.	33 feet.
(2) Yellow clay (decomposed gneiss)	5 feet.
(3) Blue clay (rotten gneiss)	7 feet.
(4) Partially rotten rock	7 feet.
(5) Solid gneiss rock.	

Water was first met in the gravel at twenty-one feet down,—in large quantity but somewhat hard. The quantity did not increase much until the clay was passed and the rock reached. There was then a considerable addition, apparently about as much as there was in the gravel,—and the water quite soft.

An analysis of the water from the gravel showed it to contain about fifty grains of solid matter to the gallon, most of which was sulphates of lime and magnesia, and only a trace of chlorine, and no organic matter.

Analysis showed the water from the rock to contain less than two grains of solid matter, mostly carbonate of lime, to the gallon, and a very little carbonate of iron.

Several holes, of two and three inches diameter and from four

to seven feet deep, were bored in the rock at the bottom of the well, and much of the rock water comes from these holes.

The temperature of the water from the gravel on the 4th of October was 59° Fahrenheit, and that of the water taken directly from the rock was 56° Fahrenheit.

To ascertain the quantity of water the well would supply,—all the water was pumped out, and then the time of filling up of each foot was recorded.

1st was filled at beginning.		16th was filled in..............	22 minutes.
2d was filled in...............	9 minutes.	17th " " "...............	23 "
3d " " "...............	11 "	18th " " "...............	23 "
4th " " "...............	15 "	19th " " "...............	29 "
5th " " "...............	17 "	20th " " "...............	32 "
6th " " "...............	18 "	21st " " "...............	35 "
7th " " "...............	18 "	22d " " "...............	43 "
8th " " "...............	17 "	23d " " "...............	48 "
9th " " "...............	20 "	24th " " "...............	58 "
10th " " "...............	20 "	25th " " "...............	76 "
11th " " "...............	20 "	26th " " "...............	101 "
12th " " "...............	20 "	27th " " "...............	162 "
13th " " "...............	20 "	28th " " "...............	251 "
14th " " "...............	20 "	28¾ stopped rising.	
15th " " "...............	21 "		

One foot in depth of water in the well is 943 gallons. Now if we take the time of filling this to be twenty minutes, which is the time required when about half the water is out, the well will supply 68,000 gallons in twenty-four hours, or if it is pumped down till the water is only two and a half feet deep and kept at that it will supply 135,000 gallons a day.

It is probable that the amount from the gravel is all a well of this size can furnish; but it may be that a much larger quantity can be got from the rock, by sinking the well deeper into it. The rock is gneiss, stratified, not very solid, nor uniform in quality, but open and with the strata almost perpendicular, so that a deepening of the well, in rock which would need no lining, would expose a much greater surface of rock and length of seams from which water could escape.

There is a slight taste to the water which is unpleasant; it probably comes from the wood of the curb, as it is well known such wood used in water pails gives a disagreeable flavor to the water, and continues to do so for a long time; and in this well

all the water from the gravel comes down behind the wood in contact with it.

The water supply for the cities of Newark, Jersey City and Hoboken, from the Passaic river at Belleville, is not quite satisfactory in quality, and the supply for Orange, Montclair, Bloomfield, Bayonne and other places, from wells is insufficient and unsafe. The question of an ample supply of pure and wholesome water for these different places which are in the same district of country, and can best be supplied from a common source, is an interesting one. And it is engaging the attention of leading citizens in all those places. The country to be supplied covers an area of seventy square miles. Its population in 1875, was:

Belleville	2,795
Bloomfield	5,425
East Orange	6,497
Montclair	4,034
Orange	10,813
Newark	123,310
Hoboken	24,766
West Hoboken	5,219
Union	4,676
Harrison	4,765
Bayonne	5,836
Jersey City	109,227
	307,363

There is an abundance of water in the Passaic river at Belleville which can be used without interfering with any rights of water-power. At Passaic and at Paterson, manufacturers claim the right to use all the water flowing in the stream, when it is low, and they use it for driving machinery. At Belleville, the sewage from Newark and salt water from the bay are liable to come up with the flood tide and pollute the water, and at all times, the sewage and manufacturers' waste from Paterson and Dundee run into and mix with the pure river water. On account of these sources of impurity, uneasiness and distrust are continually expressed in regard to the quality of water from this part of the river. And this has led to many inquiries for an available supply of water of unquestioned purity.

At the head of Little Falls, on the Passaic, the whole of the water from the watershed of that river, which has an area of 750 square miles, is collected in one stream.

The Passaic water shed is made up of that of the

Ramapo, which drains	148	square	miles.
Ringwood, which drains	108	"	"
Pequannock, which drains	82	"	"
Rockaway, which drains	165	"	"
Whippany, which drains	59	"	"
Passaic, which drains	188	"	"
Total	750	"	"

The rain which falls upon this area, furnishes all the water which runs off in its streams. The depth of the rain falling per year, upon several parts of this water shed has been carefully observed and recorded. The average yearly rainfall in New Jersey is forty-four and a half inches, and the smallest which has been observed was a little over thirty inches in depth. The latter is, of course, the only safe one to use in calculating for water supply. A great many measurements have been mado to ascertain what portion of the rainfall is lost by evaporation, and what runs off in the streams. As would be expected the amounts differ, according as the surface is rocky or earthy, hilly or flat, &c., but all of them agree that at least 40 per cent. of the rainfall runs off in the streams. That is, if there is an annual rainfall of thirty inches, twelve inches of that can with certainty be depended upon for water supply, and in ordinary seasons the quantity is much greater than that.

A square mile being 27,878,400 square feet, and the available annual rainfall on it being one foot deep, can be depended on to supply that number of cubic feet of water yearly. And as a cubic foot of water is about seven and a half gallons, the square mile will supply daily 581,063 gallons, which is more than enough to provide a population of 5,000 with 100 gallons of water each, every day. And at this rate the several streams above mentioned would furnish daily as follows, viz:

The Ramapo	85,997,324	gallons.
" Ringwood	62,754,804	"
" Pequannock	47,647,166	"
" Rockaway	95,875,395	"
" Whippany	34,282,717	"
" Passaic	109,239,844	"
Total daily supply	435,797,250	"

This is water enough for a population of five millions. But probably two-thirds of it runs off in freshets, and the streams at their lowest do not carry one-third of this quantity daily. It would be comparatively inexpensive to collect these surplus waters in times of freshet in ponds, lakes and reservoirs in the mountains, and then let them out to swell the streams when they are at their lowest in autumn.

At Little Falls, then, there is an abundance of pure soft water, coming mostly from a mountainous region. It has an elevation of one hundred and fifty feet above tide-water, and it is only seven and a half miles from the Newark reservoir, and only nine miles from that of Jersey City.

The Morris canal is supplied with water from the upper branches of the Passaic, and brings the water on a level one hundred and seventy-two feet above tide, by Little Falls, Paterson, and to Bloomfield, only two and a half miles from the Newark reservoir, and four miles from that of Jersey City. It has been proposed to abandon the canal as a means of transportation and use it and its reservoirs, Lake Hopatcong and Greenwood Lake, for supplying water. The quality of the water is good.

In addition to these projects for taking the water from Little Falls, and from the Morris canal, several others have been proposed by which water from some of the branches of the Passaic can be taken from seven to ten miles above Little Falls, and at elevations more than two hundred feet above tide, so as to furnish the supply for most of the district, by gravity alone. From any of them the quality of the water is unexceptionable. The quantity depends on circumstances to be mentioned farther on.

The large investments already made in pumping apparatus, buildings, fuel, &c., connected with the present arrangements, together with the depressed condition of business, make prudent

men dislike to consider any changes which may involve increased debts or expenses. The expenses of the Newark Aqueduct Board for the pump works, for the fuel, engineers, &c., at Belleville, in 1877, were $21,471, and they consumed 3,221½ tons of coal. The expenses of the Jersey City works for the same objects were not found in the published report for 1877, but it gives the amount of coal consumed as 5,518 tons. If the other expenses are in the same proportion, the cost of pumping water at Belleville for Jersey City must have been $34,920. This aggregate sum of $56,391 yearly expense could nearly, or quite all, be saved, if a supply could be got from some elevated ground, and drawn down by its own gravity. This sum is the interest on nearly a million dollars, and if the change could be made for that sum, there would be no increase on the present yearly expenses for water, and there could be no cause of complaint, besides there would really be a great public benefit now, and the value of it would be increasing every year.

The water taken from the Passaic river for water-supply in times of drought, or when the stream is low, will diminish the amount going to Paterson and Dundee to drive their machinery, and would have to be paid for, or else an equal quantity provided by storing surplus waters in reservoirs. Such reservoirs can be prepared of sufficient capacity and at a moderate expense.

Most of the water used in Newark is drawn from the large reservoir, which is 175 feet above tide, and most of that used in Jersey City is drawn from the reservoir, which is 161 feet high. But there are parts of both these cities which need water much higher than that in the reservoirs mentioned, and which have to be supplied by extra pumping engines. A considerable part of Orange is more than 200 feet above tide level, and there is much of the thickly settled parts of Montclair which is from 250 to 300 feet high.

If the Little Falls water-power were purchased the whole of the water could be controlled. Water-power could be used to pump supplies of water into reservoirs on the mountain near the Great Notch, at any elevations needed for supplying the population on the lower or on the higher grounds. This plan is feasible and has some advantages in regard to short distances to all the places interested.

The Morris canal is nearer at hand, and is most quickly available.

The more distant supplies have the merit of being at greater elevations, and so delivering water by gravity at places where the others would need to have it pumped up.

The economical merits of the different projects must be determined by engineers. The expense needs to be carefully considered and provided for. The water is ample in quantity and excellent in quality.

To secure these advantages for all the places interested, united action is needed. This might be accomplished by the municipal governments now existing, or it could be done by the organization of a water company or commission, made up of representative men from all places desiring the water, who would undertake the management and hold the property as a public trust, to be used for the general good.

The plan if undertaken will require some years for its proper execution, it is altogether feasible and economical and it cannot be begun too soon.

9. MISCELLANEOUS LABORATORY WORK.

IRON ORES.

Iron ores, both magnetites and hematites, continue to be sent in for examination. The inquiries are directed generally to their value for making Bessemer steel. The ores, which have been examined in the laboratory, are here reported, as they illustrate the character of some of our best ores and, also, the interest manifested in the discovery of such as can be used in these times of low prices.

1. MAGNETIC IRON ORES FROM CHARLOTTENBURGH, MORRIS COUNTY.

Four specimens were received from Martin J. Ryerson, of Bloomingdale.

The analyses showed that these ores contained of

	1	2	3	4
Metallic iron	61.420	61.470	67.420	64.940
Sulphur	0.274	3.360	0.550	0.390
Phosphorus	0.021	0.028	0.014	traces
Manganese	....	....	....	....
Titanic acid	....	....	....	1.000

Specimen No. 1 is from the opening made by the Bethlehem Iron Company. Opening is 80 feet deep, 160 feet long and on a vein 9 feet wide.

No. 2, is from an opening about 25 feet deep and 18 feet wide.

No. 3, is from a depth of 20 feet and where the vein is 8 feet wide.

Nos. 2 and 3 are from recent openings, close to one another, and near the Green Pond Mine Railroad.

No. 4 is a black compact, lamellar ore mass from the hill east of the old Charlottenburg mine.

The laboratory determinations show that these are all rich ores and all are low in phosphrus. No. 2 contains considerable sulphur. This exists in the ore as sulphide of iron, or pyrite, a mineral occurring to some extent in all the ores of that neighborhood. No. 4 differs from the others in the very small amount, traces only, of phosphorus, and in the presence of titanium. This latter constituent is not sufficient to make it difficult to work, and such ore should command the attention of manufacturers. Its richness and comparative freedom from impurities make it a desirable ore.

The location of these openings, so near railroad communication, favors working to profit.

2. MAGNETIC IRON ORE FROM LANDS OF JOHN H. BEERS, NEAR MORRIS PLAINS, MORRIS COUNTY.

Several holes have been dug, ranging between three and twenty-two feet in depth in search of a vein. The specimen came from what was considered to be a regular vein, or ore bed. The analysis indicated the following percentages:

Metallic iron	54.46
Sulphur	0.31
Phosphorus	0.04
Manganese	0.00
Titanic acid	7.70
Matters insoluble in acid (rock)	22.50

The ore is remarkable for the titanic acid, which is larger than in any of the iron ores here examined, save that of the Church mine in Hunterdon county. And it is sufficient to render the working of the ore somewhat difficult and expensive. It is quite probable that the samples analyzed may not represent all the ore of the locality. Excepting the titanic acid the ore is fairly rich and of good quality. Some of the pieces are rich, but the average is lowered by lean lumps.

3. MAGNETIC IRON ORE FROM THE NAUGHTRIGHT MINE, NEAR NAUGHTRIGHTVILLE, MORRIS COUNTY.

Two samples were received from Theo. B. Naughtright. They are reported as averages from the mine. The chemical determinations are as follows:

	1	2
Magnetic oxide of iron	89.39	82.78
Sulphur	0.27	0.041
Phosphoric acid	0.16	2.56
Titanic acid	7.50	6.40
Lime	....	2.70
Magnesia	....	0 91
Matters insoluble in acid	2.20	2.40
	99.52	97.791

	1	2
Or; Metallic iron	64.77	59.32
Sulphur	0.27	0.41
Phosphorus	0.07	1.11

Sample No. 1 is a compact, lustrous blue ore with lamellar cleavage—and as the analysis indicates—a rich ore. It represents a vein twenty feet wide.

No. 2 has a greyish aspect, due to the grains of apatite in the ore mass. The analysis shows the lime and phosphoric acid in quantity—amounting to 5 per cent. It comes from a vein four to five feet wide. Both ores contain considerable titanic acid. Were it not for this constituent both would be very desirable ores. The location of the mine is very convenient for the transportation of the ore—on the Schooley's Mountain table land near the High Bridge Railroad. It was opened in 1870.

4. MAGNETIC IRON ORE, FROM AN OPENING TWO MILES WEST OF PATTENBURGH ALEXANDRIA TOWNSHIP, HUNTERDON COUNTY.

One specimen of ore sent by J. J. Martin was analyzed, and the following results obtained:

Metallic iron	49.25
Phosphorus	0.25
Manganese	0.00
Titanic acid	1.00

The ore is lean, and includes some hornblenic mineral with the magnetite.

5. MAGNETIC IRON ORES FROM HOWELL FARM MINES, NORTH END OF JENNY JUMP MOUNTAIN, WARREN COUNTY.

From Chas. Scranton, Oxford Furnace:

	1	2	3
Magnetic oxide of iron	78.96	73.27	70.06
Sulphur	traces	1.24	0.18
Phosphoric acid	0.06	0.85	0.43
Titanic acid	0.00	0.00	0.00
Oxide of manganese	2.70	1.80	2.60
Lime	....	3.71	6.49
Magnesia	....	....	1.30
Insoluble in acid	11.70	10.20	10.10
Metallic iron	57.17	53.05	50.72
Sulphur	traces	1.24	0.18
Phosphorus	00.26	0.37	0.19

Sample No. 1 is a brownish-black, earthy mass, containing some scales of graphite. It is from the western side of the vein in shaft No. 4.

No. 2 is a hard, bluish-black ore, containing some graphite and feldspar. It is from the middle of the vein, shaft No. 4.

No. 3 is a hard, brownish-black ore, fine-grained, and from the eastern side of vein, shaft No. 4.

The analyses are not complete as appears on summing up the figures in the columns. This is due to the carbonic acid not having been determined, and the lime and magnesia in part only. Most of these bases, if not all, are combined in the form of a dolomitic limestone. The ore from the hanging-wall side of the vein (No. 3) contains the largest percentage of limestone. The phosphorus is very slight in No. 1 and is not excessive in the others. All are characterized by considerable percentages of oxide of manganese. They are excellent ores, easily worked, and adapted to the manufacture of superior grades of iron and Bessemer steel. With easier transportation the locality will develope into a mining district noted for the richness and high grade of its ores. The mines of the locality were described in the annual report for 1873. Distance from railroad communication has prevented regular mining operations.

6. HEMATITE, FROM THE FARM OF JOHN P. WENE, ONE MILE EAST OF BETHLEHEM, HUNTERDON COUNTY.

A specimen of this ore was received from Brewer, Melick & Co., who are working the mine and selling ore to the Crane Iron Company. They have mined as much as three hundred and ten tons a month. They are now getting ninety tons, besides a large amount of ochre. The analysis of the iron ore yielded the following results:

Metallic iron	55.42
Sulphur	0.10
Phosphorus	0.10
Matters insoluble in acid	6.90
Water	11.80

The analysis indicates a rich ore and of good quality.

ORES OF NICKEL, ZINC, &C.

1. FROM F. M. HARTPENCE, LITTLE YORK, HUNTERDON COUNTY.

Three specimens supposed to contain zinc.

No. 1 was a light yellow quartz ore rock, with crystals of quartz in cavities therein.

No. 2. A jaspery rock containing fine quartz crystals.

No. 3. A black slaty rock traversed by small veins of white quartz.

No zinc was found in any of them.

2. PYRITIFEROUS LIMESTONE (BLUE), FROM F. M. SHINMON'S, LAFAYETTE, SUSSEX COUNTY.

The specimens were taken from a pit about ten feet deep, dug in searching for *ore*. The pyrite occurs disseminated through the limestone.

The specimens were tested for zinc and nickel, and assayed for gold and silver, but nône of these metals were found.

3. LEWIS BARNES, PORTLAND, PA.,

Sent a sample of pyrite, said to contain nickel. An assay was made, as also tests, for nickel. Traces of the last named metal

were found. The specimen was reported as coming from near Washington, Warren county.

4. JOHN D. VAN GORDER, MILL BROOK, WARREN COUNTY.

Sent samples of a pyritiferous slate, taken from a prospecting shaft on the Kittatinny, or Blue Mountain, near Mill Brook. This shaft was twenty-five feet deep and passed through several feet of the conglomerate and then *bottomed* in the slate rock. The specimens were from the slate near its junction with the quartzose conglomerate and from the bottom of the shaft. Another lot came from another locality, but from the same geological horizon—the slate near the conglomerate. The specimens were tested for nickel and zinc, and assayed for gold and silver. None of these metals were found.

Some stress is put upon these negative determinations, particularly upon the last named, as the laboratory is receiving from time to time specimens such as these, all containing pyrite, and all reported as containing gold or silver. And these emanate not from the land owners, who naturally refer to the Geological Survey for their better information, but from prospecting miners and speculators, aided by untrustworthy and erroneous assays made by careless or unreliable chemists. And the pyrite-bearing conglomerate and slate rocks of the Kittatinny and Shawangunk mountain range has been the source whence many such specimens have come.

5. PYRITE FROM SPARTA, SUSSEX COUNTY, SENT BY CLARKSON BIRD, OF HAMBURGH.

This was supposed to contain copper. None was found in it.

6. PYRITIFEROUS SLATE ROCKS FROM HOPE, WARREN COUNTY, SENT BY A. J. SWAYZE.

The specimens were sent as zinc ores. No zinc could be detected in them.

7. TWO SPECIMENS FROM JENNY JUMP MOUNTAIN, ALSO FROM A. J. SWAYZE.

These were tested for zinc. One of them was quartz; the other hydrous silicate of zinc. There was, probably, a mistake about

the latter, although there is no geological evidence against the existence of zinc ores in the Jenny Jump mountain range. Some quartz specimens look so much like the silicate of the Ogdensburg mines that it is well for those who search for this ore to be on their guard. And this resemblance may also serve as a basis for deception, which can be practiced upon experts unless they are cautious and painstaking in their examinations of localities and of specimens.

8. SPECIMENS FROM ENOS G. BUDD, BUDD'S LAKE, MORRIS COUNTY.

These were sent on the supposition that they contained valuable metals. Examinations showed the absence of these metals.

LIMESTONES.

1. CRYSTALLINE LIMESTONE FROM SAUNDERS' QUARRY, NEAR MENDHAM, MORRIS COUNTY.

Analysis of this stone was made:

Lime	33.95
Magnesia	18.21
Carbonic acid	27.66
Alumina and oxide of iron	1.60
Matters insoluble in acid	16.40
Total determined	97.82

This limestone is a mixture of calcite, or carbonate of lime, and serpentine, and in places there is some mica and other foreign minerals. The sample sent to the laboratory was said to be an average of the stone as it is quarried for burning into lime. From the percentage of carbonic acid it would appear as if the magnesia comes from the serpentine and that the carbonate of lime constitutes about 60 per cent., by weight, of the stone. The quarry is quite largely worked for the local supply and the lime is used by farmers for the improvement of soils, for which it is highly appreciated.

2. BLUE, MAGNESIAN, LIMESTONE FROM PENNWELL, HUNTERDON COUNTY

Four specimens were received from John Warner, of Port Murray, Warren county. They were examined for the percent-

ages of lime and rock (or insoluble matters). The results of the examinations were as follows:

	1	2	3	4
Lime	29.87	29.64	25.75	26.65
Matters insoluble in acid	2.00	2.80	1.90	4.10

Nos. 1 and 2 represent: (1) first quality, or grade, and (2) second quality. No. 4 also represents second-grade stone. According to these figures all these stone are magnesian, and in none of them is the foreign matter (insoluble) above the average of limestones as quarried for lime-making. In Nos. 1, 2 and 3, it is a little below the average of blue limestones.

CLAYS.

Several clays have been received and partially examined, so as to answer inquiries.

1. CLAY FROM GEORGE SUCH, SOUTH AMBOY.

A specimen of fine, white clay was received from Mr. Such, and was analyzed. It was obtained from the Ridgway tract, near the road leading to Amboy and near the Kearney line. The results of the analysis are as follows:

Alumina and titanic acid	40.33
Silicic acid (combined)	43.75
Water (combined and hygroscopic)	14.20
Quartz sand	0.55
Potash	0.21
Soda	....
Lime	....
Magnesia	0.11
Sesqui-oxide of iron	0.97
Total	100.12

The analysis shows that this clay is remarkably free from sand and compares favorably with the very best clays of this clay district. (See report on clays, 1877.)

2. CLAY FROM THE FARM OF JOHN LONGCOR, TRANQUILITY, SUSSEX COUNTY.

This clay was drab-colored, sandy, but the sand in it was fine-grained. It is not adapted to any of the more valuable uses in pottery. For common red ware it might answer.

3. CLAY FROM SUCCASUNNA PLAINS, MORRIS COUNTY,

Sent by E. A. Quayle, of Morristown. This specimen is buff-colored and a little sandy. Analysis was not made, but a microscopic examination shows the quartz grains and irregular plates, characteristic of the kaolin clays. Its color is evidently due to oxide of iron, and that would spoil it for white pottery. It is possible that washing might prepare a paper clay out of the crude mass. It is not a fire-clay.

4. CLAYS FROM NEAR CROSSWICKS, BURLINGTON COUNTY.

From Rev. N. Pettit, of Bordentown. Two lots from this locality. Both are very sandy and unfit for pottery, but good for red-brick. The beds whence they were taken have not been opened.

5. CLAYS FROM BRICKSBURG, OCEAN COUNTY.

From H. Severance. See page 50.

MARLS.

FROM WELLS' MILLS, OCEAN COUNTY, FROM CHRISTOPHER ESTLOW.

Two samples of astringent clays, locally known as *marls*, were analyzed. (For comparison with these an analysis of a third specimen, obtained from Wheatland, Ocean county, is included in this table.)

	1	2	3
Lignite	43.690	12.380	26.150
Water (moisture)	7.900	3.900	5.200
Insoluble in acid (sand)	27.800	66.100	59.400
Alumina } Oxide of iron* }	13.062	14.361	6.456
Lime	traces	traces	traces
Magnesia	0.090	0.144	0.108
Potash	0.120	0.115	0.140
Phosphoric acid	0.038	0.039	0.044
Carbonic acid	traces	traces	0.028
Chlorine	none	traces	traces
Sulphuric acid	5.419	2.984	2.161
Sulphur	2.044	0.591	0.590
Total	100.163	100.614	100.277
Nitrogen			0.349

No. 1 is the average of the upper portion of the marl as opened in Estlow's pits.

No. 2 is from the bottom of the same pits, and it is an average.

The pits showed the following order of materials from the surface downwards:

(1) Soil and sand and gravelly earth.................... 7 feet.
(2) "Marl".................... 7 "
(3) White, sandy clay at bottom....................

The marl as freshly exposed, has a laminated structure and is largely a mass of white, quartz sand and chocolate-colored clay, containing more or less pyrite and woody matter. The latter occurs in the form of bark, leaves and wood fragments. It has a very strong smell and acid taste, and it resembles the so-called "rotten stone" of the Squankum marl pits, and the marl dug near Toms River.

Mr. Estlow has found this *marl* to be beneficial when applied some time after digging, as weathering appears to improve it. Freshly dug it is poisonous to vegetation. He thinks that it does good on clover sod.

The analyses show that it contains considerable organic matter and somewhat of sulphur and sulphuric acid. Exposure to

*A part of the iron is in combination with the sulphur as sulphide of iron—or pyrite. And the determination of the iron as oxide, instead of a part as metallic iron, makes the sums a little too high.

rains leaches these out and removes the poisonous constituent. Mixing lime with such marl ought to do good, as that would turn the sulphuric acid into sulphate of lime, or plaster. And they are deficient in this constituent. They are not, in any sense, *marls*. However, they are valuable in the sandy districts of South Jersey, where they can be used on light soils to make them heavier and more compact. The analyses show more potash and phosphoric acid than the average of soils of that part of the State, and hence their addition must improve the quality of the soils whereon they are used. But such materials cannot be transported far as they are not sufficiently rich in fertilizing elements to pay for the expenses of carrying. But they should be used on the farms and lands near the pits, or localities where they may be got.

No. 3, from Wheatland, is found overlying the clay pits of Daniel Townsend, and others. The bed there cut is thin—from a few inches to three feet thick. Over it there is the clayey soil and gravelly earth, in all, five to seven feet thick. It is full of pieces of wood (lignite) bark, leaves, &c. It is very poisonous as thrown out of the pits upon the surrounding soil. The analyses show that it resembles that of Estlow's pits. From the reports of Mr. Estlow and others, it would seem that this layer, or bed of astringent, woody earth was quite extensive and that it is to be found under the gravelly strata throughout Ocean and eastern Burlington counties. And it will have its influence in the development of the agriculture of that part of the State.

SIX SPECIMENS OF GREENSAND MARLS FROM THE FARM OF E. TOMLINSON, KIRKWOOD, CAMDEN COUNTY,

Were examined for lime and phosphoric acid, and the following results were obtained:

	Phosphoric acid.	Lime.	Carbonic acid.
Pit No. 1, A	0.83	3.34	1.67
" " " B	0.97	11.25	7.74
" " " C	2.94	4.69	......
Pit No. 3, A	2.82	3.73	......
" " " B	3.91	5.64	......
" " " C	0.90	1.30	......

Pit No. 1, A, represents a vertical section four and one-half feet overlying the shell layer. This marl is greyish, fine grained, with an occasional fragment of a shell in it. The carbonic acid combined as carbonate of lime is derived from that source.

Pit No. 1, B, represents a section of four and a half feet of the bed—the shell layer. It is quite full of fragments of Terebratula Harlani shells. The carbonic acid in it is equivalent to nearly 18 per cent. of carbonate of lime.

C, of Pit No. 1 is an average of a section six feet thick, below the shell layer.

This specimen is of dark green color, granular and shows the grains of phosphate in it. The analysis indicates a good percentage of phosphate.

Pit No. 3, north of barn.

A, from section four and a half feet thick. Greyish in color. Granular. Analysis shows phosphate.

B, also from a section four and a half feet thick. Dark bluish-green in color. Granular. Granules of phosphate of lime abound in it. High percentage of lime and phosphoric acid in it—the richest of the lot. Carbonic acid was not weighed.

C, of Pit 3, represents six feet. A green marl, inferior to the other specimens from this pit.

Taking A and B together, there is nine feet of marl whose average for phosphate of lime is about 6 per cent.—*i. e.*, one hundred and twenty pounds in one ton—which is above the average of marls in West Jersey.

Several additional specimens of marls have been received, but owing to the lateness of their reception, they have not yet been analyzed. They will appear in the next annual report.

PAINTS

FROM HENRY HANN, OF SCHOOLEY'S MOUNTAIN, MORRIS COUNTY.

The specimen was submitted to Messrs. Bush & Hollingsworth, 39 Dey street, New York, manufacturers and dealers in paints and pigments, and pronounced to be "too muddy and slate-like" and of no value for paint.

COAL

FROM WM. SCOTT DeCAMP, OF POWERVILLE, MORRIS COUNTY.

The specimen was got at Old Boonton, Morris county, and it came from a seam, or layer, about a quarter of an inch thick. Similar layers of coal are found at Newark, in Hoehnle's brown stone quarry. The occurrence of bituminous coals in our red-shale and sandstone formation is well known, but thus far no workable beds have been discovered. Inasmuch as none have been found in the many exposures of these rocks it is not worth while to explore for them, excepting along ravines or other natural sections.

In the miscellaneous work of the Survey questions are submitted for examination, which are somewhat aside from the regular subjects of a Geological Survey—yet they are of importance in the development of our natural resources and on this account they have received some attention, though not as much as is desirable.

A question of this class, is regarding the *ground rot* in sweet potatoes. These potatoes are raised with remarkable success in most parts of Southern New Jersey. Immense crops are grown, and they have the reputation of being the best in our country. Gloucester county produces 700,000 or 800,000 bushels a year. Within a few years past the farmers in some parts of that county have suffered greatly from the loss of their potatoes by what they call *ground rot.* The disease attacks whole fields at once, and after failing in this way, no soils have yet been known to regain their fertility and power of growing this crop. A large area is affected by it, and it threatens to become of importance to the whole community.

The question is fairly within the domain of scientific inquiry, and should be capable of solution, though it may need much patient investigation, and most of the experiments tried will necessarily be entire failures. But with intelligent perseverance success is certain.

Another question of the same kind, is in relation to the grape rot, which has nearly destroyed the grape crop for two or three years past. This crop is a large one now, and from our climate,

soil and advantageous position near the best markets, is capable of indefinite enlargement, the demand being constantly and rapidly increasing. But the rot is discouraging vine growers. The loss of grapes cannot be less than from *2,000* to *3,000* tons a year, and almost the whole falls on labor or on persons of small means. It is a legitimate subject of investigation, and can undoubtedly be overcome.

The disease shows itself in the fruit, and those who have examined grapes in different stages of the disease, say that it is caused by a minute fungus which falls upon the fruit, and by its growth there destroys the grape. To counteract it, the grapes have been dusted with lime, road dust and other fine powders, but so far without decided success. Some have acted on the assumption that the disease is only a consequence of weak or incompletely developed vines, owing to exhaustion of the fertility of the soil or the insufficiency in it of some essential elements which should be supplied in manures. It is certain that this is the case with some other fruits, the apple in particular; apple trees respond to generous fertilizing as surely as corn or wheat do, and those apples which are apt to rot on the tree, by the liberal use of special manures are changed to sound, good keeping fruit. This subject is one of present importance and of sufficient magnitude to call for aid from the State.

The cranberry rot is another source of heavy losses to some of our citizens. It is a special crop grown on boggy or swampy grounds. But the cranberry has become of more importance in New Jersey than in any other State; and utilizes profitably, lands that for any other purpose have been nearly worthless. Crops of cranberries, when successfully grown, are enormously large and very profitable, and the supply about equals the demand. But if growing them could be made certain, prices would be lower, more consumers could enjoy the fruit, and a branch of staple industry would be improved.

The disease which affects the cabbage and turnip crops, which is known as anbury, fingers and toes, or club root, is in some of our soils very damaging. In some soils not a crop can be grown without considerable losses from this disease, and in many cases an interval of several years must pass before a second crop can be grown on the same ground. In other soils this difficulty does

not occur. It is a proper subject for scientific inquiry, and there is reasonable ground to believe that both cause and cure can be found.

These are by no means all the inquiries put to us, but they are prominent specimens of what is needed for New Jersey lands.

10. STATISTICS.

MINING STATISTICS.

IRON ORE.

The product of the iron mines in the State during the year 1878, according to the tonnage of the Morris Canal, the Central and the Delaware, Lackawanna and Western Railroads, and the returns from the Oxford Furnace mines, amounts to 409,674 tons. The zinc mines yielded, according to the data from the same sources, 14,467 tons. These figures correspond closely with those for 1875, when the estimate for iron ore was 390,000 tons. They are lower than those for 1871, 1872, 1873 and 1874. From these and from *estimates* for the years 1876 and 1877, there is reason to hope that iron mining in New Jersey has reached its lowest point, and is now increasing its annual product. The future for our rich mines of iron and zinc ores, with their unequalled advantages of contiguity to our greatest markets, remains more promising than ever before.

GREENSAND MARL.—TRADE AND STATISTICS.

Greensand marl, the well known natural fertilizer of the southern part of the State, continues to be used extensively throughout the marl district. The liberal use of marl has made this district one of the most fertile in our country. In some places it has been used to such an extent as to modify very materially the texture and composition of the soil. It is applied in smaller quantities, but with satisfactory results, outside of the limits of the marl belt. The country southeast of this belt needs such a fertilizer both as an amendment to the soil and as contributing the inorganic constituents necessary for the plant food. All of the railroads traversing this part of the State carry marl. Its

use is, however, much less than the needs of this district, and various causes are given for the comparatively small aggregate which is carried by them. The low priees of farm products, the scarcity of money and the cost of the marl have affected the marl trade and reduced the tonnage of the marl carriers. The cost ought to be lessened and the price be lowered so as to bring it within the means of all thrifty farmers. Such a reduction would induce experiments and increase and extend the use of marl. And such a policy would surely react to the profit of the transportation companies in the additional freights coming from larger areas under cultivation and the increased fertility of the lands now in farms. The country southeast of the marl belt is capable of producing as large an aggregate as that of the latter, provided it be improved by the liberal use of this marl and be farmed judiciously. In order to ascertain the present condition of the marl trade and, especially as it bears upon the clearing up and improvement of the southeastern and southern parts of the State, inquiries were addressed to the several marl companies and the following letters in answer were received. It has been thought proper and advisable to print the letters, as they not only state the condition of the marl trade, but also account for its depression and suggest points for improvement. And it is hoped that they may lead to such changes as will advance their interests as well as those of the carriers and the farmers:

O. C. HERBERT, MARLBOROUGH, MONMOUTH COUNTY,

Writes: "I have looked over my marl account and I find that I have sold from January 1st, 1878 to December 25th, 1878, two hundred and eighty cars of marl, each containing three hundred bushels, making eighty-four thousand bushels. Sold to farmers (who dig and cart their own marl) by the foot, over eight thousand feet, which we estimate to be about one hundred and sixty thousand bushels, thus making about two hundred and forty-four thousand bushels of marl sold during the past year.

"Marlborough, December 24th, 1878."

As to prices Mr. Herbert writes:

"Your question in relation to the marl I answer as follows:

Marl delivered at	Freehold	4¼	cents per bushel.
" "	Tracey's	6½	" "
" "	Jamesburg	6¾	" "
" "	Cook's	4	" "
" "	Morganville	4	" "
" "	Mount Pleasant	4¾	" "
" "	Matawan	4¾	" "
" "	Van Wickle's Woods	4¾	" "
" "	on cars, Marlborough	3	" "

"Marlborough, January 3d, 1879."

W. E. BARRETT, SUPERINTENDENT OF THE SQUANKUM MARL COMPANY.

"Our sales of marl the present year have been very light, amounting to 150,000 bushels. The falling off is due almost entirely to the "hard times" and scarcity of money among farmers in our section and not in any degree to want of confidence in marl as a fertilizer. Our price for marl at the pits is two and a half cents per bushel, and from five to ten cents on the railroad according to distance. I do not give prices at the different stations because there is some prospect of a reorganization of this company by new parties, and a list of prices furnished now might not be correct by the time your report is published.

"Farmingdale, December 24th, 1878."

A. A. YARD, SUPERINTENDENT OF THE SQUANKUM AND FREEHOLD MARL COMPANY

Declined to comply with the request regarding amount sold, but stated that their "sales this year have been very light." He enclosed circular of prices from which the following is taken:

SQUANKUM AND FREEHOLD MARL COMPANY,

Will deliver marl at the following prices per ton of twenty bushels, including freight in not less than one hundred tons:

On the Freehold and Jamesburg Agricultural Railroad.

Squan	$1 20	Tracey's	$1 30
Allenwood	1 20	Hoffman's	1 30
Howell	1 20	Jamesburg	1 30
Freehold	1 20	Rhode Hall	1 40
Manalapan	1 20	Dayton	1 40
Englishtown	1 25	Monmouth Junction	1 45

On the United Railroads of New Jersey.

South Amboy	$1 55	Princeton Junction	$1 55
Old Bridge	1 45	Penns Neck	1 60
Spotswood	1 40	Princeton	1 60
Prospect Plains	1 35	Plainsboro	1 50
Cranbury	1 40	Monmouth Junction	1 45
Hightstown	1 45	Deans Station	1 50
Windsor	1 50	Van Nortwick's	1 60
Newtown	1 50	Four Mile Tank	1 60
Yardville	1 55	Kingston	1 50
Bordentown	1 60	Rocky Hill	1 55
White Hill	1 65	New Brunswick	1 60
Florence	1 70	Piscataway	1 65
Burlington	1 75	Metuchen	1 70
Edgewater	1 75	Union Town	1 70
Beverly	1 80	Rahway	1 70
Delanco	1 85	Linden	1 70
Riverton	1 90	Elizabeth	1 75
Palmyra	1 95	Waverly	1 75
Camden	2 00	Newark	1 80
Trenton	1 70	West End	1 90
Lawrence	1 60	Jersey City	2 00

Perth Amboy Branch.

Avenel	$1 70	Benton's	$1 70
Woodbridge	1 70	Perth Amboy	1 75

Millstone Branch.

Millstone Junction	$1 60	Middlebush	$1 65
Voorhees	1 60	East Millstone	1 70
Harlingen	1 80	Hopewell	1 85
Blawenburg	1 80	Pennington	1 90

Pemberton and Hightstown Railroad.

Hightstown	$1 45	New Egypt (North)	$1 60
Woodsheds	1 50	New Egypt (South)	1 60
Sharon	1 50	Cookstown	1 65
Imlaystown Station	1 55	Wrightstown	1 70
Davis	1 55	Lewistown	1 70
Cream Ridge	1 55	Shreve's Road	1 75
Hornerstown	1 60	Pemberton	1 75

Central Railroad of New Jersey.

Spring Lake	$1 35	Red Bank	$1 40
Sea Plain	1 35	Middletown	1 65
Ocean Beach	1 35	Holmdel	1 65
Asbury Park	1 35	Matawan	1 70
Deal Beach	1 40	Cliffwood	1 80
Elberon	1 40	Morgan	1 85
Long Branch	1 40	South Amboy	1 90
Branchport	1 40	Perth Amboy	1 95
Shrewsbury	1 40		

Belvidere Delaware Railroad.

Coal Port Junction	$1 70	Titusville	$1 85
Asylum	1 75	Moore's	1 85
Ewing	1 80	Lambertville	1 90
Washington's Crossing	1 80	Flemington Railroad Junction	1 90

Flemington Railroad Branch.

Mount Airy	$1 90	Murheid's	$1 95
Barber's	1 90	Copper Hill	2 00
Ringoes	1 95	Flemington	2 05

At points on the Central, Morris and Essex and Belvidere Delaware Railroads more distant from Farmingdale the price ranges from $1.90 upwards.

GENERAL G. MOTT, OF THE CREAM RIDGE MARL COMPANY.

Writes: "The Cream Ridge Marl Company sold last year 6,460 tons of marl.

"The present price at the following points is as follows:

Imlaystown	5 miles.	$1 05	per ton.
Prospect Plains	17 "	1 30	"
Spotswood	24 "	1 40	"
South Amboy	34 "	1 55	"
Newtown	17 "	1 25	"
Trenton	30 "	1 50	"
Princeton Junction	31 "	1 50	"
New Brunswick	35 "	1 55	"
Hightstown	13 "	1 20	"
Jamesburg	20 "	1 35	"
Old Bridge	25 "	1 45	"
Windsor	14 "	1 20	"
Bordentown	24 "	1 40	"
Lawrence	35 "	1 55	"
Monmouth Junction	25 "	1 40	"

"Trenton, Dec. 23d, 1878."

THE PEMBERTON MARL COMPANY

Did not respond to the letter of inquiry, respecting sales and prices.

JOHN S. COOK, SUPERINTENDENT OF THE VINCENTOWN MARL COMPANY

Writes: "Owing to the hard times with farmers and the high rates of the railroads the sales have been very much reduced. But now the railroad has reduced the freights and our sales since December 1st have been increased considerably. Our average sales since opening the pits have been about 10,000 tons per annum.

"Our prices for marl are at

Trenton, 29 miles	$1 50	per ton.
Princeton Junction, 39 miles	1 60	"
New Brunswick, 55 miles	1 65	"
Hightstown, 30 miles	1 50	"

"Vincentown, December 23d, 1878."

No report was received from the

FOSTERTOWN AND SOUTH BRANCH MARL AND TRANSPORTATION COMPANY.

Of the sales along the *Camden and Atlantic* and the *Philadelphia and Atlantic City Railroads* during the year 1878, no accounts have been received.

FROM I. C. VOORHIES, SUPERINTENDENT OF THE WEST JERSEY MARL AND TRANSPORTATION COMPANY

The following letter was received:

"DEAR SIR:—Our business has been small for the year 1878, and I feel very much ashamed of it. I could not do any better. Our farmers are very much discouraged. The price of grain, &c., is very low. Very few farmers have made both ends meet. We have done a considerable business in lime this year, having sold and delivered 46,668 bushels of stone and gas lime—nearly all stone lime. Farmers complain very much of the price of marl, and think it ought to be lower.

"Enclosed you will find a price list for the different railroads, which will, I hope, prove what you wish.

Statement.

AMOUNT OF MARL SOLD AND DELIVERED BY THE WEST JERSEY MARL AND TRANSPORTATION COMPANY IN THE YEAR 1878.

January	560	tons.
February	none	
March	160	"
April	2,192	"
May	864	"
June	none	
July	456	"
August	476	"
September	794	"
October	164	"
November	none	
December	592	"
	6,258	"

Price List.

THE WEST JERSEY MARL AND TRANSPORTATION COMPANY

Will deliver marl on and after January 1st, 1873, on the *West Jersey Railroad and branches*, at the following prices per ton:

West Jersey Railroad.

Camden	16	miles,	$1 55
Gloucester	13	"	1 50
Westville	11	"	1 45
Woodbury	8	"	1 30
Mantua	4	"	1 20
Barnsboro	3	"	1 10
Marlboro	1	"	......
Glassboro	4	"	1 20
Union	6	"	1 30
Harding	8	"	1 35
Monroe	9	"	1 40
Elmer	12	"	1 45
Palatine	15	"	1 50
Husted's	17	"	1 55
Finley's	20	"	1 65

Bridgeton	24	miles,	$1 70
Cook's Crossing	14	"	1 50
Newkirk's	15	"	1 50
Daretown	17	"	1 55
Paulding's	18	"	1 60
Yorketown	19	"	1 60
Oakland	22	"	1 65
Alloway's	24	"	1 70
Middletown	25	"	1 75
Acton's	26	"	1 80
Salem	29	"	1 85
Clayton	7	"	1 30
Franklinville	10	"	1 40
Iona	13	"	1 45
Malaga	14	"	1 50
Newfield	16	"	1 55
North Vineland	17	"	1 55
Vineland	21	"	1 65
Millville	23	"	1 80
Manumuskin	33	"	1 85
Belleplain	39	"	1 95
Woodbine	43	"	2 00
Mount Pleasant	45	"	2 05
Seaville	48	"	2 10
Swain's	53	"	2 20
Cape May Court House	...	"	2 25
Millertown	59	"	2 35
Rio Grand	62	"	2 35
Bennett's	64	"	2 45
Cold Springs	...	"	2 45
Cape May	68	"	2 55

Swedesboro' Railroad.

Mullica Hill Road	9	miles,	$1 33
Tatum's	10	"	1 35
Parkville	10	"	1 37
Ogden's	11	"	1 39
Berkley	12	"	1 40
Clarksboro	13	"	1 43
Gibbstown	14	"	1 45
Wolfert's	15	"	1 50
Tomlin's	16	"	1 52
Asbury	17	"	1 55
Rulon's Road	18	"	1 55
Swedesboro	19	"	1 60

Bridgeton and Port Norris Railroad.

Brickville	25 miles,	$1 73
Bellevue	27 "	1 76
Fairton	28 "	1 78
Westcott's Station	29 "	1 82
North Cedarville	30 "	1 84
Cedarville	32 "	1 86
Newport	34 "	1 90
Dividing Creek	37 "	1 97
Buckshutem	39 "	2 02
Mauricetown	40 "	2 03
Port Norris	44 "	2 10

"The company do not furnish less than four tons. Marl delivered between stations at the price of station beyond. Marl must be removed within fifteen days after delivery or agents may re-sell it.

"*Terms.*—Three months' credit will be given by giving note, payable in bank. If cash is paid on delivery, interest will be allowed for three months; if a longer credit is desired, interest will be charged after three months.

"Woodbury, Dec., 1878."

Summary.

O. C. Herbert, (per railroad)	4,200 tons.
O. C. Herbert, (per teams)	8,000 "
Squankum Marl Company	7,500 "
Squankum and Freehold Marl Company	(no report.)
Cream Ridge Marl Company	6,460 tons.
Pemberton Marl Company	(no report.)
Vincentown Marl Company	5,000 tons.
Fostertown and South Branch Marl and Transportation Company	(no report.)
West Jersey Marl and Transportation Company	6,258 "
Woodstown, (Dickinson Pits)	2,500 "
Total (reported)	39,918 tons.

As compared with the sales which were reported for 1873, there is a falling off of about 70 per cent., or, in other words, the marl carried by the railroads of the State in 1878 did not amount to much over one-third of the tonnage of 1873.

11. PUBLICATIONS OF THE SURVEY.

The annual reports of the progress of the State Geological Survey are printed among the documents of the State, and they are very generally distributed by the members of the Legislature among their constituents. A liberal number of copies is also placed at the disposal of the members of the Board of Managers and the Geologist. The demand for them however, is large, and those of 1876, 1874, 1873 and 1872 are all distributed, so that for those years no copies can be furnished.

The Geology of New Jersey, an octavo volume with a portfolio of maps, published in 1868, can still be supplied, though the number of copies left is not large.

The report on the Fire and Potters' Clays of New Jersey, with a map of the clay district, which was completed about the time the Board met last year, has been widely distributed both at home and in foreign countries. The edition is probably sufficient for the present demand.

The large Geological Map of the State is mostly distributed, only a few copies being left.

The Geological Map of Northern New Jersey, which was printed in colors, and first distributed with the Annual Report of 1873 is out of print. A very large number of copies has been distributed.

The Centennial Map of New Jersey on a scale of six miles to an inch, and showing geographical features only, was prepared by the Survey, and a very large number has been distributed.

The proper method of distributing the results of our Geological, Topographical and Economical Survey, is a question which has not been satisfactorily settled with us, and is equally unsettled in most other countries. At first the Board resolved to sell the reports and maps at the cost of paper, printing and binding, and a considerable number of copies of the Geology of New Jersey and some of the maps were sold in that way, but there

were always some copies at the disposal of the members of the Board and of other State officers, and the chance of getting some of these without paying for them, led those who really wanted them to delay buying. From the way the printing is done the amount of free distribution has increased, till now no copies are sold nor have been for two or three years past. As the object of the Survey is to make known our natural products and resources, it may be said that we must do it by advertising, that is by free publication and liberal distribution, just as in private business, and that the waste or misappropriation of a considerable part of the publication should not discredit the method as long as we continue to thrive in using it.

The Pennsylvania reports are sold at cost of printing and paper, but in fact most of them are given away.

The results of the Geological Survey of Great Britain are prepared and printed with great care and at heavy cost, and the price put on them is so high that few buy them. At the meeting of the British Association in Dublin, in August last, a memorial and resolution was passed stating that the prices at which maps and books were held were so high, as to keep them entirely from the public, and requesting the Board having the matter in charge to revise their list of prices, so as to give the reports free circulation among those desiring to use them.

The French Geological maps too, are held at high prices, and I think, few of them are sold.

12. EXPENSES.

The expenses of the Survey are kept strictly within the appropriation. The bills have been regularly presented to the Auditing Committee and approved every quarter, and there are no outstanding accounts.

13. PERSONS EMPLOYED IN THE SURVEY.

Prof. John C. Smock, Assistant Geologist, has been steadily employed during the year in geological work, surveying the deposits of glacial drift, the soils of southern New Jersey, and in miscellaneous work.

Edwin H. Bogardus, Chemist of the Survey, has been engaged in the laboratory, analyzing soils and ores, and in other work answering questions which are submitted to the survey.

Geo. W. Howell, C. E., has been for a part of the year leveling and surveying for the topographical map of the country between Orange Mountain and the Hudson river. In this work he has been assisted by Mr. C. C. Vermeule, a graduate of Rutgers Scientific School.

Prof. Edward A. Bowser has been engaged in determining geographical positions at various places in the State in connection with the United States Coast Survey.

My own time has been occupied with office work, miscellaneous inquiries submitted to the survey, work connected with water supply, drainage, agriculture, &c., and in a special study of the resemblances of our glacial drift unstratified and partly stratified, to glacial deposits now accumulating in the Alps.

APPENDIX.

INDIAN AND OTHER PREHISTORIC REMAINS OF MAN.

In last year's report allusion was made to the interesting questions raised in regard to the remains of the people who formerly occupied our country. It is much to be desired that all remains of this kind should be secured and described. They are fast being destroyed or lost. It is earnestly requested that all implements, such as arrows, spears, knives, axes, mortars, pestles, &c., should be placed in some public collections in the State where they will be preserved, and that notes be made public of the location of habitations, burial places, &c., or any other facts which may be curious or interesting in regard to these early inhabitants. At Greenwich, in Cumberland county, there are marks of the foundations of their houses, which appear as if they were made partly or wholly underground, and not like ordinary wigwams. The same marks have been seen in other parts of the county; and in one instance something like a wooden floor has been found a few feet beneath the level of the ground.

Prof. Samuel Lockwood, of Freehold; Dr. Charles C. Abbott, of Trenton; Luke W. Brodhead, Esq., of Water Gap, Pa.; Dr. Brakeley, of Belvidere; Drs. E. J. Fithian, George B. Wood and Ephraim Holmes, of Greenwich, Cumberland county; Dr. Theodore T. Price, of Tuckerton, and Dr. Maurice Beasley, of Dennisville, have given a great deal of intelligent attention to this subject; and there are many other collectors in the State who may find interest in communicating with any of these gentlemen or with this Survey.

CONTENTS.

INDEX.

A.

B.

C.

D.

E.

F.

G.

GEOLOGICAL SURVEY OF NEW JERSEY.

ANNUAL REPORT

OF THE

STATE GEOLOGIST,

FOR THE YEAR

1879.

With the Compliments of

GEORGE H. COOK,

State Geologist.

New-Brunswick, N. J.

Please acknowledge receipt of Report.

TRENTON, N. J.:
WM. S. SHARP, PRINTER AND STEREOTYPER.
1879.

BOARD OF MANAGERS.

[is Excellency GEORGE B. MCCLELLAN, Governor, and *ex-officio* President of the Board........................Trenton.

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[ON. ANDREW K. HAY........................Winslow.

II. CONGRESSIONAL DISTRICT.

[ON. WILLIAM PARRY........................Cinnaminson.
[ON. H. S. LITTLE........................Trenton.

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GEOLOGISTS.

EORGE H. COOK, STATE GEOLOGIST........................New Brunswick.
OHN C. SMOCK, ASSISTANT GEOLOGIST........................New Brunswick.

To His Excellency George B. McClellan, Governor of the State of New Jersey, and ex-officio President of the Board of Managers of the State Geological Survey:

SIR—I have the honor to submit herewith my annual report on the progress of the State Geological Survey for the year 1879, as required by the "Act to complete the Geological Survey of the State," approved March 30th, 1864.

With high respect,

Your obedient servant,

GEORGE H. COOK,

State Geologist.

REPORT.

INTRODUCTION.

The Geological Survey of New Jersey has been continued during the year 1879 as in preceding years. Charged with work of an economic and practical character, the results of which are of immediate use, the annual reports are necessarily much occupied with these results. There is, however, joined to this, some work of a scientific character, and every year something is added to the knowledge of our geology. For the proper delineation and location of the various natural products found in the State, good maps are needed, and it has been found necessary to give much attention to the construction of such maps. The nature of the work of the survey will be best understood by an examination of the list of topics which are discussed in this report.

1. U. S. Geodetic Survey of New Jersey.
2. Topographical map of Northeastern New Jersey.
3. Economic Geology of New Jersey, with a map.
4. Triassic or Red sandstone formation of New Jersey.
5. List of iron mines in the State, with notes.
6. Soils.
7. Drainage.
8. Water supply.
9. Artesian or driven wells.
10. Miscellaneous laboratory examinations and analyses.
11. Statistics.
12. Publications.
13. Expenses.
14. Persons employed.

1. UNITED STATES GEODETIC SURVEY OF NEW JERSEY.

The first element in the geographical description of any place is its location on the surface of the earth; in other words, its latitude and longitude. This has been ascertained for many places, with more or less accuracy, by means of astronomical observations made by astronomers and navigators, after which, by measurement with bearings and distances, the locations of other places have been determined. The results of this kind of work, however, were not accurate enough to meet the requirements of the present day, either on land or along our shores. The United States Coast Survey was set in operation for the benefit of navigators. Its work was to determine with accuracy the location of the prominent landmarks on our whole coast. It has done its work well; it has originated new and more accurate methods for ascertaining the location of points, and has computed and published, in lists and on its maps, the exact latitude and longitude of hundreds of places along the coast of our country. New Jersey is favorably situated to be benefited by this work, and along the whole eastern side of the State, and up Delaware bay and river, above Trenton, the latitudes and longitudes of a sufficient number of places have been determined as part of the work of surveying the coast. In addition, the field of operations of the coast survey has been enlarged so that it now has the work of determining latitudes and longitudes across the continent from the Atlantic ocean to the Pacific, and it also has authority to aid States which are conducting geological or topographical surveys—ascertaining for them, at the expense of the general government, the geographical positions of places in such States away from the coast.

Under this authority its work has been going on, to a moderate extent, in our State for the last five years. The system of primary triangles which was originally marked out across middle of the State, from New York to Philadelphia, and thence down the coast, has now been extended so as to take in the whole of the northern end of the State; the *reconnaisance* has been made, the principal and many of the secondary and tertiary points have been located, and a sufficient number

of observations have been made from several of these points to compute their position accurately.

The labor and expense attending this work are very great. These will be better appreciated when it is remembered that the sides of the triangles are some of them nearly 30 miles long, and in our hazy atmosphere the signals which mark the angles cannot, on the average, be seen accurately one day in the week, and the times when they can be seen are entirely uncertain, so that constant watch has to be kept; that each angle has to be measured at least seventy-two times, and these measurements must not vary from each other more than 6″, and the sum of the angles thus carefully averaged must not vary 2″ from 180° plus the computed spherical excess. As angles of several triangles (8 to 12) are measured from the same station, it may require three or four months of patient observations to complete the work at one such station.

When this work is done, however, and the computations completed, the positions of the points on which observations have been made are known to within a very few inches—in some cases, which have been verified, not more than 1 or 2 inches, on lines which were several miles long.

For the work in northern New Jersey eleven primary stations have been established, in addition to the two old stations which were occupied in connecting these stations with the work formerly done. Of these eleven primary stations, work has been completed on three besides the two old ones, and that on a fourth is two-thirds done.

The *reconnaisance* of northern New Jersey is chiefly done, and the work of observations is not quite half done. The field in southern New Jersey is not so large as in the northern part of the State, and has not yet been begun. It is to be hoped that the United States Coast and Geodetic Survey, with its completely organized methods of work and its admirable equipments for field operations, will carry their survey of New Jersey through to its completion, so as to give us an accurate basis for our maps.

2. TOPOGRAPHICAL MAPS.

The topographical map of the country between the Hudson river and the mountains west of Newark, and extending from the Raritan to Paterson, was well advanced last year. This year it has been extended so as to take in the country west to the main range of the Highlands. It now covers an area of 746 square miles. It has been drawn on a scale of 3 inches to a mile, and the elevation of the surface is shown on the map by contour lines at every twenty feet of elevation in the hilly parts, and at every ten feet in parts nearer level or where the rise is more gentle. To insure the accuracy of this map in those parts over which the United States Geodetic Survey had not yet extended, it was found necessary to extend their triangulation over a small part of the country covered by the northwestern part of this map; and 13 tertiary points have been observed upon by our survey, so as to make sure of the accuracy of the basis of this map. The result shows the necessity for this preliminary work, for the old county and State maps are found to be fully one-third of a mile out in their locations on those parts of the map farthest from the stations of the geodetic survey. This work has involved labor and expense, but they are well repaid, and it is believed that the map is now right in its location to within a small fraction of 1″; and the elevations are marked so nearly that there is no spot on the whole 746 miles of the map where the height of the surface above sea level cannot be seen within 3 or 4 feet.

This map covers the ground which is occupied by more than half the population of the State. The country is developing very fast, and the increase in population and wealth is rapid and steady. The map furnishes needed information in regard to locations, drainage, laying out roads, and for local and general improvement and embellishment.

For engraving, it can be reduced to a scale of 1 inch to the mile without much crowding of the material, and will make a map about 3 feet square. A scale of 1½ inches to the mile would make a better map, and being then only about 4½ feet square would not be unwieldy in size.

A similar topographical survey should extend over the whole Highland range of mountains. Our great deposits of iron and zinc ores are all in this range. The immense value of the ores, the increasing demand for them, and the occasional discovery of new and rich mines, show that it is of public importance to help on the development of this region. Information in regard to the exact location of these deposits, and their relations to or connections with each other, cannot be furnished by private enterprise. It is the proper work of the geological survey, and it is proposed to begin it as soon as the necessary arrangements can be made.

3. MAP OF NEW JERSEY—ECONOMIC GEOLOGY.

The map which accompanies this report is drawn on a scale of six miles to an inch, and is intended to show the leading features of our economic geology.

1. By means of colors, and by the columnar section it gives the geological structure and formations of the State.

2. By means of conventional marks it shows the location of the principal mines of iron and zinc ore.

3. By reference to the characteristic colors on the columnar section, and on the map the beds of limestone, marl and fine clay are easily found.

4. The colors on the map furnish a clue to the location and origin of the characteristic soils of the State.

All the larger geological formations of the United States, except the coal formation, are found in New Jersey. They occur in parallel belts or zones, usually some miles in breadth, which traverse the State in a northeast and southwest direction; and they are so regular in this respect, that a person may travel on a northeast and southwest road from one side of it to the other, and see but a single geological formation. But, on the contrary, if he should journey from Barnegat, on the Atlantic coast, northwest to Port Jervis, on the Delaware, he would cross every one of its formations.

Its oldest rocks make up the mountain range which crosses the northern part of the State from northeast to southwest in parts of Sussex, Passaic, Bergen, Warren, Morris, Hunterdon and Somerset, and which is known in New York as the Highlands, in Pennsylvania as South Mountain, and is here without any general name, but its individual ridges are known as Ramapo Mountain, Hamburg Mountain, Schooley's Mountain, Trowbridge Mountain, Watnong Mountain, Musconetcong Mountain, Scott's Mountain, Marble Mountain, and others. The newer geological formations lie upon each side of this central ridge, and run parallel with it; the Silurian and Devonian limestones and other formations being mostly in a broad belt upon its northwest side, and a little in its valleys; the Triassic red sandstone

adjoins it in a broad belt on its southeast side; the Cretaceous clays and marls stretch across the State in a belt just southeast of the red sandstones, and the Tertiary and the recent formations lie southeast of the marls. The columnar section of New Jersey formations on the map shows their order and relative position, as they have been proved by measurement and comparison at the various places where they occur in different parts of the State. It does not, however, give the relative thickness of the different formations, those in the lower part being much thicker in proportion to the higher, and the layers or strata are not level as represented here, but are almost all of them slanting or *dipping* downwards towards the northwest or southeast. The Azoic, Cretaceous, Tertiary, and most of the Recent, have a prevailing dip towards the southeast, while the Silurian, Devonian and Triassic mostly dip towards the northwest.

The Azoic rocks are the Archaic of Dana, and the Laurentian of Canada; they are the oldest of the geological series, and are made up of granitic, gneissic and other crystalline rocks, and contain no fossils. The mountain ranges which cross the northwestern part of the State, and which are known by the names of Ramapo, Warwick, Hamburgh, Pochuck, Schooley's, Mine, Musconetcong, Scott's, and other mountains, are made up of these rocks. They cover an area of about 772 square miles in New Jersey, and they contain all the mines of magnetic iron ore.

The country which this formation occupies is hilly or mountainous in all its parts. The northeastern end of the belt in this State is rough, and has many boulders scattered over its surface, so that much of it is still in forest. The southwestern end of the belt is much smoother, and has few loose boulders on its surface, and a considerable portion of it is cleared and in good farms.

The Silurian are the lowest and oldest rocks of the geological series which contain fossils. The rocks are sandstones, limestones and slates. These formations occupy many of the valleys between the mountains of Azoic rock and the whole of a belt of country of 15 or 20 miles wide, northwest of and adjoining these mountains. A marked feature of this district is the high, narrow and long ridge which is near its northwestern border, and which is known in New Jersey as the Blue Mountain, in New York as the Shawangunk Mountain, and in Pennsylvania as the Kittatinny Mountain. The divisions of the Silurian are the Potsdam

Sandstone, including the Green Pond Mountain Conglomerate, which is the oldest, and then, in order, the Magnesian Limestone, the Trenton Limestone, the Hudson River Slates, the Oneida Conglomerate, the Medina Sandstone, and the Lower Helderberg and associated limestones. The rich farming lands of Sussex and Warren counties are on the Magnesian Limestone, and the grazing and dairying lands are on the Hudson River Slates. The area covered by these formations is about 650 square miles.

The Devonian rocks have a very limited exposure in New Jersey, along the Delaware from the New York State line to the Walpack bend. The area included is about 40 square miles. There are some valuable limestones and some good soils, but much of it is encumbered with glacial and terrace drifts. The Oriskany Sandstone, the Caudagalli Grit, the Corniferous and the Onondaga Limestones are well exposed, but the Marcellus shale appears only in a very limited space on the bank of the Delaware.

The Triassic Formation includes the red sandstone of the State. Its soil and rocks are characterized by their red color, and its surface is marked by many abrupt mountain ridges of trap rock. It occupies the belt of country next southeast of the Azoic region. It is about 20 miles wide, and extends entirely across from the Hudson to the Delaware. Its area is 1543 square miles. The rock contains many beds of excellent freestone, which is extensively quarried. The soil, though not rich, is generously responsive to good cultivation, and has been specially noted for the excellent quality of the fruit grown upon it.

The Cretaceous Formation is characterized by containing extensive and valuable beds of fine white clay, and of green sand. The belt of country in which it occurs adjoins the Triassic on its northwest border, and extends from the Raritan bay and the seaside to the Delaware river near Salem. It is 90 miles long and from 12 to 15 miles wide, and has an area of 1491 square miles. The white clays occupy the northwestern side of the belt, and the green sand marls the southeastern side. The clays are extensively used for making common and fine pottery, and fire-bricks made from them are among the most infusible known, and they are more used where refractory materials are needed than any other in the country. The green sand marls have been largely used by farmers, and have produced most remarkable effects on the soil, restoring fertility to worn-out and abandoned fields, and bringing productiveness and thrift to the whole country where they are used.

Tertiary Formations. The southern portion of the State is mainly occupied by these formations. They consist of sand and clay, and the surface is covered with a thin soil, which is not naturally very productive. Some of the clays contain shells enough to be designated as marls; and extensive beds of the purest of white sand, for glass-makers' use, are common. A large part of it is still in forest. Some good farms are found on this formation, and in and along its borders are some of the best farms in the State.

Post-tertiary Formations. The formations which belong to this division are the glacial drift which covers much of the northern third of the State; the banks of sand and gravel which, in the form of terraces or level-topped hills, occupy much space in valleys; the alluvial deposits along the borders of streams, and the tide-marshes and sand beaches which border the State along the seaside and on Delaware bay.

2. MINES OF IRON AND ZINC ORE.

The Magnetic Iron Ores are all in the Azoic formations, and occur in beds, interposed conformably between the layers of the Gneiss rock. They sometimes extend for a considerable distance, but are not continuous like the rocks themselves; thinning out to nothing at their edges, and in many cases descending beneath the surface in long folds or rolls to an unknown depth. The mines have long been worked, and much of the ore is carried to furnaces near the coal mines in Penn sylvania. There are sixteen blast furnaces in the State, all of which are largely run upon this ore.

The mines now opened number nearly two hundred, and are capable of supplying one million tons of ore annually. The ores are rich, and being near the great markets of the country, find a ready sale. They vary in purity, some containing a little phosphorus, others sulphur, while others are almost entirely free from these impurities. Many of the ores in the northwest, or Pequest belt, contain oxide of manganese, and are in demand for making Bessemer steel.

The manufacture of iron in New Jersey was begun by Lewis Morris, at Tinton Falls, in Monmouth county, as early as 1682. Forges for working the magnetic ore into bar iron were built at Whippany, Morris county, about 1710. The blast furnace at Oxford was built in 1742; and iron has been a staple product of New Jersey from those early

days. The annual product, however, has been subject to great variations, with the business of the country, the improvements in methods of manufacture, and the convenience of locations for cheap transportation, abundant supplies and ready markets.

Red Hematite Iron Ores have been found in a few places, but not in large quantities.

Limonite, or Yellow Hematite, is found in beds, mostly in the magnesian limestone.

Zinc Ores are mined at Stirling Hill and Mine Hill, in Sussex county. Oxide and silicate of zinc and franklinite are the principal ores. Much of the ore is worked directly into the white oxide of zinc, for painters' use, but there is a large quantity used in making spelter of a superior grade. The residuum left after making zinc oxide, contains oxides of iron and manganese, and is used in making spiegel-eisen.

These mines are noted among metallurgists for the remarkable minerals which constitute the ore, and for their unequaled size and richness. The demands for our whole country are largely met from these mines. The ores are accompanied by a white, crystalline limestone, which contains a small quantity of carbonate of manganese. This peculiar limestone, which is easily recognized by the brown or black color of its weathered surfaces, has been traced 40 miles towards the southwest, but as yet no other remarkable beds of zinc ore have been found.

3. The rich deposits of limestone, marl and clay, unlike those of iron and zinc ore, are found in continuous beds, extending entirely across the State, and of almost uniform quality, so that the working of them depends upon the convenience of their location, and their nearness to good transportation or to market. The study of this map, on which the great markets of our country are laid down, and the lines of transportation marked out, in connection with the deposits of these useful substances, will show where the supplies needed can be most easily procured.

4. The map gives the best possible exhibit of the variety of soils found in the State, as they partake to a greater or less degree of the same composition with the rocks or earths on which they lie. *The soils have all originated from the underlying rocks.* Some of them have since been mixed by the glacial drift, and others have been sorted into finer and coarser portions, or into clayey and sandy earths by the agency of rains and running water, and soils which are obviously of the same origin may differ widely in physical condition on account of

differences in drainage; but both chemical and skillful management and tillage prove that the general principle stated above is correct. The composition and character of the different classes of soils in the State are given in a subsequent part of this report.

RED SANDSTONE OR TRIASSIC FORMATION.

This is the geological formation which occupies the middle and most thickly settled part of New Jersey. It is bounded on the east by the Hudson river from below Jersey City, north to the State boundary line; its breadth on the north, where it extends on into New York, is from the Hudson river to the Erie railway, at Sufferns station. Its northwestern boundary is a somewhat irregular, southwesterly line from Sufferns to the Delaware river, a little above Milford. The formation extends on beyond the Delaware into Pennsylvania, but that river is its western boundary in New Jersey from the last-named point, as far down as a mile above Trenton. Its southeastern boundary is in a line from the last-named point, onwards in a northeast direction to the south of Princeton and New Brunswick, till it reaches the shore of Staten Island sound, near the mouth of Woodbridge creek, and thence along the sound to the Hudson river. Its characteristic red rocks and earth are well known to all travelers, and its remarkable capabilities for agricultural and other industrial improvements have been well known and highly appreciated from the first settlement of our country. But its geology has been more difficult to study out than that of any other part of our country, and at the present time it offers several problems for solution, which are of a most perplexing character.

Its rocks consist of red sandstone, shale and trap—the former two being sedimentary rocks and the latter one of igneous origin. It contains no limestones of any account; a layer about two feet thick, and extending on its outcrop for a mile or two on the east side of the valley near Feltville, and crowning the county line between Somerset and Union. Conglomerate rock of magnesian limestone is found in numerous places along the northwest border of the formation, and some limestone pebbles are found in the pudding-stone at Paterson, near the Passaic Falls.

The rock is of various degrees of hardness, but generally it is much

softer and less tenacious than limestone. The softer portions disintegrate rapidly when exposed to the weather, a single season's exposure to the sun and rain being sufficient to crumble large masses of it into small grains, and two or three years' exposure brings it down into fine, clayey earth. In most cases the shales disintegrate more rapidly than the sandstones, and as these two rocks alternate with each other in thick beds and strata, as well as in other cases, in thin layers, they wear away with very different degrees of rapidity. The unevenness of the surface of the country is due to the fact that the soft rocks have disintegrated most rapidly, been carried away by rains and streams, and left the valleys, while the harder rocks have worn away more slowly, and now constitute the hills and ridges. Examples of this are to be found everywhere in the district where this formation extends.

At several places along the northwestern border of the formation ridges start out from the Highlands and extend southerly for from 1 to 3 miles. Holland Hill, near the Delaware, Gravel Hill, just east of the last named, hill west of Pattenburg, hill between New Germantown and Pottersville, hill west of Peapack, and Mt. Paul, north of Peapack, are such ridges. Their rock is largely made up of quartzose, gravel and cobbles, cemented but slightly. The material of which these hills are made, and their north and south direction, form points of interesting inquiry regarding them. On the eastern side of the State, and from the Hudson to the Highlands, along the New York boundary, there are not less than ten ridges, which are equally high and marked in their direction, but the material is not so distinctly quartzose.

The quarries are all in the ridges or on the side-hills, and none in the bottom of the valleys. Those which have produced good building stone are not found, however, in all places where the rock is hard enough to resist the action of the weather. The rock in the high hills in north part of Bergen county is too coarse-grained and crumbles too easily to make good building stone, though it resists the action of the weather. And in Hunterdon county the high barrens and swamps there are partly sandstone and partly an indurated shale, but they have no quarries from which valuable building stone can be got. The stone at various places along the west foot of the Palisades is very handsome, and would make good building stone, but it is not quarried. The stone from the quarries at Newark, Bloomfield, Belleville, Pater-

son and Little Falls is very largely used. The quarries in Washington Valley and at Martinville have produced some very handsome drab building stone. But in all the country from New Brunswick and Princeton towards the northwest, shaly and soft rocks prevail, and no good quarries of brownstone are opened. Along the Delaware the sandstones and shales alternate along nearly the whole breadth of this formation, and good quarries of brownstone are opened.

At Milford extensive quarries of flagstone are opened. And at Woodville, in Mercer county, there are quarries of a flagstone which is of remarkably smooth and fine grain.

The trap-rocks have characters by which they are easily distinguished from the sandstones and shales. They are all of a dark gray or greenish gray color in fresh fractures, and where they are weathered they are of a dull, rusty color, varying from brown to almost white. They are much more likely to be mistaken for granite or gneiss, but can be distinguished by containing no mica, and, in the solid portions, no quartz. The rock is, in some parts, of a uniform quality, and in other parts is made up of grains more or less coarse, consisting of hornblende and a feldspathic mineral. It varies much in solidity and hardness—some of it being soft, cellular and dull in fracture, other varieties being hard, tough, homogeneous and bright in fracture, and still others very hard, coarse and crystalline. The ridges farthest east are composed of the hardest and most crystalline rocks, and the rock diminishes in hardness in ridges farther west. Whether this difference is due to a difference in composition, or is simply due to a difference in age, or in depth to which it has been worn down below the original surface, is not determined.

The rock from Bergen Hill, from the first of the Watchung Mountains and from Goat Hill has been used extensively for making paving blocks, for Telford pavements, for ballasting railroads, and for rough, strong masonry. It is extremely tough, and stands the weather well, and for the purposes for which it is used is better than any other rock.

Thin seams of coal have been found in the rock in many localities, and some expensive work has been done in the hope of finding it in quantity profitable for mining, but without success. There is no reason to dig or bore for coal, for the structure and dip of the rock are such that all its strata crop out on the surface, and the thickness

and quality of the strata can be seen there as well as at any depth beneath.

Copper ore and metallic copper have been found in the sandstone, and also at the meeting of the sandstone and trap in many localities. And mining operations have been begun at many of them at various times for the past 150 years; but all have been unsuccessful. The ore is disseminated in the rock, and is not in regular veins, so that its continuance in any particular working is uncertain, and in all past workings it has failed.

The following is a list of brownstone, flagstone and trap-rock quarries opened in different places. It might be considerably enlarged:

BROWNSTONE.

Alpine, Bergen County.—A grayish-white feldspathic sandstone has been opened and quarried to a very slight extent on the western slope of the Palisades Mountain, about a quarter of a mile northwest of the village, and on the road to Closter.

Englewood, Bergen County.—A considerable amount of gray and light-colored sandstone has been quarried in the drift on the western slope of the Palisades Mountain, north of Englewood, and on towards Tenafly. The abundance of the stone in the drift-earth indicates a solid mass under the drift, and resting upon the trap-rock. The beauty of the stone and the ease with which it is worked make it a desirable building material. And such stone is to be looked for near the foot of the mountain, between Tenafly and New Durham.

Homestead Station, Hudson County.—A red sandstone of inferior quality has been opened at the foot of Bergen Hill, a few rods east of the station.

Saltersville, Bayonne City, Hudson County.—Red sandstone for local uses has been obtained at Forty-fourth and Forty-seventh streets. It appears to lie in a belt between trap-rocks on the east and west.

Hohokus, Bergen County.—There is an old quarry near the place.

Paterson, Passaic County.—There are three quarries in the eastern face of the First Mountain, and south of the city, whence a large quantity of brownstone has been taken. The larger part of it has been used in the city. These quarries are conveniently located for trans-

portation, being near the Morris canal and the Delaware, Lackawanna and Western R. R.

Stone House Plains, Essex County.—There is a quarry northwest of this place, in the eastern face of the First Mountain.

Llewellyn Park, Essex County.—Sandstone has been quarried in the mountain side in the Park.

Orange, Essex County.—Bell's quarry is in the mountain, west of Orange.

Avondale, Essex County.—A new quarry has been opened near the N. Y. & L. E. R. R.

North Belleville, Essex County.—These quarries are on the bank of the Passaic. They have furnished a large amount of superior stone.

Newark, Essex County.—Three quarries are here worked. They are on the ridge west of the Passaic, and in the northern outskirts of the city. The ridge is 150 to 170 feet high, and has a northerly trend. The southernmost quarry is that of Copeland Bros. Next to it, northward, is the Newark Brownstone Co.'s quarry. It has reached a depth of 40 or 50 feet, and has been opened several hundred feet in length. North of the Bloomfield avenue is Philip Hoehnle's Newark stone quarry. All of these quarries are in steady operation, and their stone has a wide market.

Snake Hill, Essex County.—Red sandstone is quarried to a limited extent in the western face of Snake Hill.

Franklin Lake, Bergen County.—Red sandstone is quarried for a local market on the western side of the lake, and near the Second Mountain.

Haledon, Passaic County.—There is a small quarry here, in the valley between the two ranges of trap-rock.

Pompton, Passaic County.—James Ludlam's quarry, northeast of Pompton Furnace, meets the demands of the country around it. There is much variation in the rock at the quarry—from shale to coarse conglomerate.

Schuyler's Basin, Passaic County.—There is an old quarry at this place, on the east bank of Pompton Feeder.

Hook Mountain, Morris County.—John H. Vreeland's quarry. This quarry supplies a local demand for stone.

Little Falls, Passaic County.—Robert Beatty's quarries at this place were extensively worked many years ago, and much handsome stone

was sent away from here. Of late they have not been so actively worked.

West Orange, Essex County.—A new quarry, in the face of the Second Mountain, and near the Centreville road, is reported as a very promising locality.

Washington Valley, Somerset County.—This quarry is between the First and Second Mountains, and two miles north of Plainfield. It is not in operation. A light drab stone was obtained here, which was used in Plainfield with great favor.

Martinville, Somerset County.—Bartle's quarry, at this place, continues in steady operation, and meets the demand of a large circle of surrounding country. Some of the stone is of a light color. The upper beds are red, and are used for rough work. It is five miles from Bound Brook, in a north-northwest direction.

Pluckamin, Somerset County.—Dow's quarry, in the red sandstone, a half a mile east of Pluckamin, is not now worked.

Millington, Somerset County.—The Millington quarry is in the southern foot of Long Hill. It is near the N. J. West Line R. R.

New Providence, Morris County.—A quarry at the foot of Long Hill.

Basking Ridge, Somerset County.—The quarry near the village is not worked.

Five-Mile Lock, Delaware and Raritan Canal, Somerset County.—An old quarry, which has not been worked in many years.

New Brunswick, Middlesex County.—James Neilson's quarry in the city is occasionally worked for local market. The stone is red in color and somewhat shaly.

Lawrence Brook, Middlesex County.—Sandstone has been quarried at Weston's Mill, near New Brunswick, and at Provost's quarry, near Milltown, but they have not done more than supply a very limited demand in the immediate neighborhood.

Heathcote Brook, near Kingston, Middlesex County.—A dark-colored, slaty stone was here found. The place has been idle for many years.

Kingston, Somerset County.—The red sandstone quarry at this place is in operation, and supplies the Delaware and Raritan canal with stone for slope walls. It is on the bank of the canal, and near the Rocky Hill R. R.

Ten-Mile Run, Somerset County.—There is a small quarry at Ten-Mile Run.

Rocky Hill, Somerset County.—The more or less altered sandstone at Rocky Hill, for half a mile north from the depot, and on the east side of the canal, has been quarried at intervals, but not much of late years.

Princeton, Mercer County.—The quarry near the canal, southeast of the town, furnished stone for several of the college and seminary buildings. There is a much smaller quarry in the place. They do not send stone to any distance.

Greensburg, Mercer County.—The Greensburg quarries are four miles north of Trenton, and on the east side of the canal and Belvidere Delaware railroad. Beginning at the south, they are as follows: Keeler's, Walton & Brother's, Moore's, James Green's, Peter Clark's. The strata opened in these quarries consist of red, shaly and gray sandstone. The strata worked in these several quarries consist of red and gray sandstones, and in thick beds. In some of the beds there are scattering white quartz pebbles. The thick beds, the ease of working, and convenient location give them advantages, and they are steadily worked. The stone finds a market in Trenton, Camden and Philadelphia, and at other points along lines of canal and railroad transportation. Their capacity is large, and can be indefinitely increased.

Lambertville, Hunterdon County.—The blue indurated shale is here quarried for building purposes in the town. The red sandstone, further from the trap rock, is also quarried to a small extent for local needs.

Brookville, Hunterdon County.—Here are two quarries, one of which was opened lately.

Stockton, Hunterdon County.—There are several quarries along the upland bluff in Stockton, and thence to Prallsville and on northwest, up the river. Peter Best works one in the village.

Prallsville, Hunterdon County.—In and near the village there are four quarries, but only one is in operation, which is worked for the Pennsylvania Railroad Company. The stone in these Stockton-Prallsville quarries is of a light-grayish shade, and occurs in thick beds. Some of these contain scattered pebbles of quartz. It can be quarried in large blocks, and it is liked for heavy work. It has had wide use in the construction of bridge piers and abutments.

Raven Rock, Hunterdon County.—Here are two quarries, but they are not worked to any great extent.

FLAGSTONE.

Milford, Hunterdon County.—Flagging stone is obtained near Milford, at the quarries of Smith Clark, M. McGuire, and Rawlings. Large-sized stone are quarried and are sold in Trenton, Easton, Philadelphia and points along the Delaware river valley.

Woodville, Mercer County.—Burroughs' flagging stone quarry is actively worked for the surrounding county. Stone slabs of as large size as can be transported, true on the surface and as smooth as slate, can be furnished.

TRAP-ROCK.

Palisades and Bergen Hill.—Along the eastern face of the Palisades Mountain, and in Bergen Hill, Jersey City, the trap-rock is quarried at several points, for paving-blocks and dock-filling. The supply of stone for these uses is practically inexhaustible.

New Durham, Hudson County.—On the western foot of the hill, stone is here quarried on lands of Abram W. Duryee, for Telford road material.

Bergen Cut, Hudson County.—The cutting of the new line through the hill, for the Pennsylvania railroad, affords a large amount of trap-rock, which is used for road-ballasting and for Telford roads.

Snake Hill, Hudson County.—There is an extensive quarry on the western point of the hill, which is worked by D. Brennan, Jr., of Orange, for materials for Telford roads and streets.

Orange, Essex County.—The rock from the steep face of the south-east side of the First Mountain is extensively worked for materials to make Telford roads; and various avenues about Orange and Newark have been made models of driving-roads by its use.

Paterson, Morris Hill, Passaic County.—The trap-rock of this hill is being rapidly removed for road material.

Plainfield, First Mountain, Somerset County.—Considerable stone has been quarried north of the town, in the gap of the First Mountain, for road-making in the vicinity.

Rocky Hill, Somerset County.—M. A. Howell, of New Brunswick, quarries paving-blocks and road-making materials, as well as finer.

broken stone, for walks, &c., in the side hill east of the railroad and canal, and south of the Rocky Hill station. It has remarkable advantages for cheap transportation.

Smith's Hill, Titusville, Mercer County.—A large amount of stone has been obtained on the southwestern point of this hill, at the side of the Belvidere Delaware railroad, and one mile north of Titusville, and from its convenient location is finding use over a very large district of country.

Lambertville, Hunterdon County.—A very large amount of stone has been worked here out of the large blocks which lay on the steep westerly end of Goat Hill. The fast rock has also been quarried. The paving-blocks are sold in Trenton, Camden and Philadelphia. The smaller stone, unfit for blocks, and the chippings, are used for road-making materials. Two firms have been at work at this locality. As at Smith's Hill, this place also is convenient to both canal and railroad, which run along its foot.

Rocktown, Hunterdon County.—Trap-rock from the surface of Sourland mountain at this place has been worked at Flemington for monumental bases, and with great success.

FOSSILS.

Fossils are not common in this formation in New Jersey. No marine shells have been found, but there have been remains of land plants, footprints of birds or reptiles, and fossil fish found in different places.

At the Belleville quarries thin seams of coal and impressions of the stems and branches of plants are not uncommon. A fragment of the stem of a plant with surface markings like the lepidodendron was found, and is now the property of Mr. David Hitchcock, of Orange. It is a very plainly-marked, flattened stem, 8 inches long, 4½ wide, and 1½ thick. Photographs of this were taken and sent to Prof. L. Lesquereux, of Columbus, Ohio. He returns the following answer:

"The photographs are sufficient, if not for specific determination at least for positive reference of the specimens to Lepidodendron. Even I should say that the specimens represent *L. Weltheimianum Prest.* as distinctly as a specific representation can be made upon a decorticated trunk of Lepidodendron. *L. Weltheimianum* is a leading species of the old red sandstone found here, as in Europe, from the sub-

carboniferous measures down to the Devonian, while until now we do not have any remains of Lepidodendron of any kind from the upper coal measures (Permo-Carboniferous), or from higher up than the Pittsburg coal.

"*L. Weltheimianum* is recorded only once from the true coal measures; this by Eichwald, from the carboniferous sandstone of Russia. But European authors, among others Goeppert, doubts the identity of the Russian species with *L. Weltheimianum*, which is moreover extremely variable, and has been described already under about thirty different names."

Another fragment has since been obtained from the same quarries by Dr. Skinner, of Belleville, and is now in our possession. It is 7 inches long, 5½ inches wide, and 1½ inches thick, and is as plainly marked as the first. Other and smaller specimens somewhat like the above have also been found in the quarries in Newark. If these fossils are sufficient to determine the geological age of these beds, they put it in the Upper Carboniferous, at least, which is lower than has been heretofore claimed for it. A larger and more complete collection of such fossils must be made if possible.

Vegetable impressions are found in large numbers at the quarries of Mr. Smith Clark, of Milford, but most of them are fragmentary and indistinct. Those which can be seen plainly enough for identification resemble the Equisetum and some coniferous plants. They are evidently much newer than the fossils at Newark and Belleville.

Fossil fishes have been found at several places: in the shales on the bank of Rockaway river, below Boonton; in the old stone quarry at Pompton; in the copper mines in Washington valley; and in other places in the shales at the west foot of the mountain between Bound Brook and Pluckamin. A collection of fishes was made by the late W. C. Redfield, of New York, and his descriptions and conclusions were published in *Am. Jour. of Science* (Vols. 36, 44 and 45) in 1843 and earlier. He described several species of the genera Paleoniscus and Catopteris. His specimens were from Boonton and Pompton. Since that time numerous specimens have been collected by others; we have a number among the specimens belonging to the survey. Mr. I. C. Russell has also made very extensive collections of them, and placed them in the hands of Prof. J. S. Newberry, of Columbia College, New York, from whom we may expect soon to have full

and complete descriptions of all the different species found in our State.*

Footprints of various three-toed animals have been found in different places in the sandstone; one was found by Prof. Gale, of New York, at Pompton, and noticed in *Silliman's Journal* as early as 1840. The specimen was in relief, and about 6 inches long. Other rather indistinct impressions were found near Boonton by different persons, and others in the quarry near Milford. In 1867 a slab of stone was found in the brook near Tumble Station, on the Belvidere Delaware R. R., on which there were tracks in order, as if made by one animal. They are three-toed, each toe about 3 inches long, and the tracks somewhat in pairs. The specimen is in the cabinet of Rutgers College.

Mr. I. C. Russell obtained a good specimen in relief from the sandstone near Boonton, in 1878. It is 6.2 inches long and 5.5 inches wide. During the past autumn the survey has obtained several large slabs of sandstone, with footprints, from the quarry of Mr. John H. Vreeland, near Whitehall, in Morris county.† The slabs are now in the Museum of the Geological Survey at Trenton. Two of the slabs have the tracks in depression, and two others have them in relief—that is, they are casts of the first. One of the slabs is 4½ by 6 feet, and has on it 26 tracks, most of which have the toes from 3 to 4 inches long, but one of them has the whole track, 12 inches long. The other slab is 5 by 7 feet in size, and 25 tracks can be counted on it; most of these also are small, but there are two large tracks which appear as if made by the same animal, and are 3 feet apart. Great numbers of such tracks have been found in the sandstone of the Connecticut valley, and a special study was made of them by Prof. Ed. Hitchcock, of Amherst College, Mass. The results of his work, "The Ichnology of New England," were published by the State of Massachusetts in a quarto volume of XII. and 220 pages and 60 plates, and the Ichnological Museum at Amherst College is filled with his specimens. Our fossil footmarks are of the same general character, and probably of the same species.

* By the generous assistance of H. W. Crane, of Boonton, a fine suite of these fossil fishes was secured for the museum of the Geological Survey at Trenton.

† These specimens were obtained through the generous assistance of H. W. Crane, of Boonton, and were quarried by F. Wilson Van Duyne.

There is much still to be done in the study of these interesting fossils; but one conclusion may safely be drawn, which is that the formation is altogether of fresh-water origin.

The sandstone and shale rocks are all in uniform layers, and with a prevailing dip towards the northwest; and none of it dips regularly towards the southeast. The variations from the regular dip are limited in extent; and the change in direction is not more than a quadrant on either side. A section taken along the Delaware river, from Trenton to Milford, which is a distance of 30 miles, shows a uniform dip towards the northwest of from 5° up to 20°, and with an average of 15°. A section following up the Raritan river, and onward towards the northwest, shows a northwest dip, averaging 8°, for a distance of 9 miles, when the dip changes to the northeast, and so continues through the remaining 14 miles of the formation in that direction. A section following in a northwest direction across the formation in the basin of the Passaic, shows nearly the same change with that in the Raritan section. The principal changes of dip appear to be, in some unexplained way, connected with the direction of the trap ridges, and are near them.

TABLE OF DIPS OF THE RED SANDSTONE.

I.—Section along the East Bank of the Delaware, from Trenton to Milford.

DIRECTION.	AMOUNT.	ROCK.	LOCALITY.
N. 60° W.	25°-27°	Sandstone.	Trenton, near Cadwallader place.
N. 8° W.	10°-12°	Sandstone.	Walton & Bro.'s quarry, Greensburg.
N. N. W.	10°-15°	Sandstone.	Green's, Greensburg.
N. W.	15°-20°	Red Shale.	Titusville.
N. 35° W.	22°-25°	Altered Shale.	Lambertville.
N. 45° W.	20°	Sandstone.	Brookville.
N. 25° W.	20°	Sandstone.	Prallsville. (Old quarry.)
N. 30° W.	15°	Altered Shale.	Raven Rock.
N. 40° W.	10°	Altered Shale.	Point Pleasant.
N. 15° W.	15°	Red Shale.	Near Tumble Station.
N. 45° W.	5°-8°	Red Shale.	Frenchtown to Milford.
N. 40° W.	20°	Flagstone.	Clark's quarry, Milford.
N. 60-70° W	15°-20°	Conglomerate.	Pebble Bluff, N. W. of Milford.
N. 60° W.	40°	Conglomerate.	Johnson's Ferry.

II.—Section along the Lower Raritan and the Central R. R. of N. J., from below New Brunswick to Lebanon.

DIRECTION.	AMOUNT.	ROCK.	LOCALITY.
N. 40° W.	10°	Shale.	Martin's Dock, Raritan river.
N. 15° W.	5°	Shale.	New Brunswick.
N. 40° W.	12°	Shale.	New Brunswick.
N. 40° W.	10°	Shale.	Five-mile lock. (Old quarry.)
N. 20° W.	5°	Shale.	Between Bound Brook and Middle Brook.
N. 50° E.	5°	Shale.	R. R. cut, one mile east of Somerville.
N. 40° E.	8°	Shale.	R. R. cut, near North Branch.
N. 35° E.	21°	Shale.	One-half mile S. E. of White House.
North.	30°	Shale.	One and a half miles W. of White House.

III.—Section from near Plainfield across the Trap Ridges and the Valleys to Basking Ridge.

N. 30° W.	15°	Shale.	Near Ambrose's brook, Samptown.
N. 15° W.	10°–15°	Shale.	Old copper mine at Plainfield.
N. 30° W.	8°	Shale.	Near Coontown.
N. 75° E.	30°	Shale.	Basking Ridge, N. W. of village.
N. 20° E.	15°	Sandstone.	Quarry at Millington.

IV.—Section from Weehawken west to Green Village and the Highlands.

N. 60° W.	20°	Sandstone.	Weehawken.
N. 20° W.	15°	Sandstone.	Almshouse, Snake Hill.
N. 20° W.	10°	Sandstone.	Newark, brownstone quarries.
N. 50° W.	7°–10°	Sandstone.	Llewellyn Park. (Quarry.)
N. 70° W.	10°	Sandstone.	Yost's quarries, bet. First and Second Mts.
S. 85° E.	7°	Shale.	Olmstead's Mills, west of Green Village.

V.—Section from Fort Lee on the Hudson west to the Highlands.

N. 60° W.	88°	Sandstone.	Fort Lee.
N. 75° W.	Gentle.	Sandstone.	Near Closter Landing.
Westerly.	Gentle.	Sandstone.	Hohokus.
N. 80° W.	10°	Sandstone.	Paterson, Pope's quarry.
N. 50° W.	10°	Sandstone.	Little Falls, Beatty's quarry.
S. 80° W.	20°	Sandstone.	Pompton, Ludlam's quarry.
S. 60° W.	25°	Shale.	Pompton, near Ransley's hotel.
Northwest.	7°	Sandstone.	Hook Mountain, John H. Vreeland's quarry.
S. 70° W.	8°–9°	Sandstone.	Rockaway river, S. E. of Boonton.
N. 40° W.	20°	Conglomerate.	Union Hill, Sufferns, N. Y.

The thickness of the formation appears to be very great. A well in New Brunswick was bored into it 450 feet deep. Several wells in Newark are bored to depths of from 400 to over 600 feet, and one in Paterson is nearly 1300 feet deep—all in red sandstone and shale. It is assumed that the materials of the rock were deposited in horizontal

layers, as sediments now are, and that these layers have since been raised on their southeastern edge or lowered on their northwestern edge, so as to take the inclination they now have, and that, then, their elevated edges have been worn off so as to leave the surface of the formation as it now is. The thickness of the body of the rock becomes a matter of trigonometrical calculation. The measure across the formation from one side to the other may be treated as the hypothenuse of a right-angled triangle; the dip of the strata constitutes one of the angles of the same triangle, and the leg opposite to the angle of dip is the thickness sought. Calculated in this way the formation along the Delaware should be 43,760 feet, or over 8 miles thick; and on the Raritan and Passaic sections the thickness, estimated in the same way, is 5179 feet, or a little less than one mile.

But this enormous thickness is not accepted by most persons, and the question is considered to be an unsettled one.

The materials of which the rock is composed appear to have been derived in the first place from the older rocks which lie on both sides of the belt. The rock composing the southeastern margin of this formation contains mostly grains of feldspar instead of quartz, as if it had been made from a very feldspathic gneiss or granite, such as is found in great quantities on that side of the formation. The rock composing the northwestern side of this formation is remarkable for containing fragments of magnesian limestone, such as is found in place in the older rock formations on that side of the red sandstone belt. In many specimens of the sandstone (brownstone) from this formation, small fragments of red sandstone or shale are to be seen, as if the rock were made of older sandstone which had been worn away in fragments, grains and mud, and deposited anew to make this rock. It is to be remarked, too, that the stone containing magnesian limestone does not extend more than a mile or two in from the northwestern boundary in any case. There is also in one case at the Great Falls of the Passaic in Paterson a conglomerate which contains some pebbles and even cobbles of true limestone. In addition to the rock containing gneissic pebbles and feldspathic grains along the southeastern margin of the formation, there are several long outcrops of strata near the middle of the formation which are quite light-colored with grains of feldspar.

Just above New Hope, Penna., on the west side of the Delaware

river, and nearly opposite Lambertville, magnesian limestone of the Silurian Age is exposed in a belt of a mile or more wide, and 6 or 8 miles long. The red sandstone is on both sides of this belt of limestone, and lying as the limestone does near the middle of the formation, it gives reason to suppose that in other places also the older rock is not far beneath the surface of the red sandstone, and that the latter rock is not so thick as the calculations given would lead us to expect.

The trap-rocks, which form the abrupt mountain ridges which are so characteristic of this formation, are of igneous origin, and appear to have come up from the interior of the earth since the deposition of the sandstone and shales. They are true eruptive rocks, as can be seen in many places where they have broken across the strata of other rocks, but in general they appear to have found their way to the surface by opening a passage between the layers of sedimentary rocks, rising until they have reached their present position. And their prominence above the surface is due to the rock being so much harder than the sandstones and shales, that the latter have been worn down and washed away by the action of the elements, while the trap itself has been but little affected by it, and now stands prominently above the red sandstone in these mountain ridges. As the layers of red sandstone all dip towards the northwest, the trap, in rising between them, has presented its outcropping edge towards the southeast, and now, when the sandstone is worn away, these great bodies of trap present a series of almost perpendicular ledges on their southeastern faces, whilst their northwestern slopes are comparatively smooth and gentle. This is well seen in the Palisades along the Hudson river, and in the Watchung Mountains west of Newark. The trap ridges are not continuous in long lines, but are in crescent-form sections, of lengths varying from two to ninety miles, and these, with scarcely any exception, have their convex sides towards the southeast. The beds of sandstone and of the intruded trap have the same dip, and it is remarkable that at the curved ends of these crescent-shaped ridges the dip of the sandstone conforms to their curvature, so that at the northeast end the dip is southwest, and at the southwest end it is northeast. To this latter statement some exceptions have been noted in the inside of the great curve of the Hook Mountain, in Rockland county, New York, where the trap has broken directly across the beds of stratified sandstone.

To account for the apparently great thickness of this formation, it

has been thought that faults, running in the line of the strike of the rock, have occurred, in which the rock on the northwest side of the fault has risen, and that on the southeast side has sunk, and that in this way we get a repetition of the same layers of rock. There is so much uniformity in the color and composition of these rocks, they being all either sandstone or shale, and the rock on exposed surfaces decomposes so rapidly, that it is difficult to either prove or disprove this theory. Along the Delaware, a few miles above Trenton, there is a succession of stone quarries which have the general appearance of being repetitions of each other—as if they had been made by a series of faults which had brought the same layers up in the different quarries, and careful search has been made for such faults, but they have not been found. In the rocky cliffs along the Delaware, above Milford, several faults are to be seen, and they are all in the way to increase the apparent thickness of the formation, but it is not possible to determine the amount of the off-set. Similar faults have been observed in the rock cuttings on the Easton and Amboy railroad, near Sidney Church, in Hunterdon county. On the Central Railroad of New Jersey, in the rock cuttings about a mile east of White House station, faults are exposed. In the deep rock cutting on the New York and Greenwood Lake railroad, just east of the Passaic river, there is a very plainly marked fault. Slickensides are also to be seen in many places, but there is nothing in the surface or on the adjoining sides to indicate the extent of this movement.

Folds or curves in the strata are very uncommon, and the beds themselves are of almost uniform thickness throughout. None are to be seen along the Delaware. On the Easton and Amboy railroad, near Sidney Church, there are some curved strata.

The occurrence of magnesian limestone in the belt, at different places, is not favorable to the idea of the great thickness of the formation; it seems as if they might be like islands in a shallow sea, which project above the surface, and show that in other places they are not far below the surface. At various places along the northwestern edge of the New Jersey belt, Silurian limestones are found in place, and the sandstone overlies them. The same limestones are also to be seen above the surface and extending six or seven miles southeast into the red sandstone belt, and cross-wise of its strata, near Clinton, in Hunterdon county. The same stone is also to be seen on the west side of

the Delaware, near the middle of the belt, in a long strip which runs many miles towards the southwest. The boring of the deep well at Paterson is watched with much interest, to see if it will not prove something in regard to this question of thickness.

From the change in the dip of the strata near the trap-rocks, as well as from the great depth of the earth* down to the solid rock, inside the curves of some of the crescent-formed trap ridges, it has been questioned whether there have not been local changes of level in the surface of the sandstone during and since the eruption of the trap-rocks.

The facts thus far collected and stated would lead to the conclusion that this formation has been deposited first from materials on its borders, and chiefly from those on the southeastern side; that it has formed slowly, and through a very long period of time, and that in the course of its deposition there has been a slow and long-continued subsidence of the land on its northwestern border, and an equally long-continued elevation of the land on its southeastern border. In this way the strata, which were originally horizontal, would be tilted up so as to dip towards the northwest, and their out-cropping edges would be exposed to the weather and would be liable to be worn off, and their abraded material would be carried forward towards the northwest to be deposited again, and thus to form new beds of the same kind of rock. The new beds would extend farther towards the northwest, thus widening the formation in that direction, and covering ground where the lower beds which have their out-crop on the southeast border are entirely wanting.

The trap rock has evidently been intruded into the red sandstone after the deposition of the latter was complete, for the over-lying sandstones are altered by the trap-rock near them as much as the under-lying ones are, and besides, no fragments or pebbles of trap are found in any beds of the sandstone, shale or conglomerates of this formation.

After the close of this period of time, the high ground southeast of the red sandstone must have undergone a gradual subsidence, during which the plastic clays of the Cretaceous age must have been deposited

* At the farm of Judge Lathrop, in the Great Swamp, in Morris county, an iron pipe was driven 165 feet without reaching the rock, though the basin in which it lies has solid rock on all sides, nearly as high as the surface of the earth where the well is bored, and this basin has either been worn out to this depth, or the solid rock has sunk down when the trap was thrown out.

as we now find them, in the same fresh-water basin with the red sandstone and over-lapping the latter. This is apparent from the absence of marine shells and all calcareous matter from them, and the great abundance of trees and fresh-water vegetation still to be found in them. It was not till the time of the clay marls and green sands of the Cretaceous age that this southeastern ridge had sunk low enough to admit the salt water and the marine animals and plants which characterize that age, and which we now find over-lying the plastic clays; and the clays which must originally have been deposited in beds which were level, or dipping towards the northwest, are now found dipping towards the southeast at an angle of less than one degree.

LIST OF IRON MINES IN NEW JERSEY—WITH NOTES.

For six years, from the panic in 1873 to the autumn of 1879, the iron mining industry of the State participated in the general business depression of the country. It suffered more than some other branches of industry, in consequence of the extreme dullness of the iron market. Throughout 1873 and 1874 there was a general expectation that business would revive, and the mining companies were in hopes that the depression would soon give way to steady and profitable work. In consequence of this the contraction did not begin at once, and the minimum of production was not reached the first year of the panic. The older and larger mines were kept in operation, although in all of them there was at the outset a reduction in the working force. The effect upon the work of prospecting and the opening of new mines was more marked, and scarcely anything was done in these directions. In many cases the working of the larger and more important mines was made necessary by the terms of leases, or of contracts for the ore. One of the first results of the contraction was the surplus in the labor market in all the mining centres. The loss of work sent many elsewhere, and there was a temporary check to the growth of the population, and in some localities a diminution. A large part of the labor supply found work in the anthracite coal fields of Pennsylvania, and in the mining camps of the far West. The price of labor fell over 100 per cent. The dullness in the iron market led to greater economy in mining, and the expenses per ton were much reduced. Notwithstanding these economies in production, the extremely low prices for ore and the slack demand compelled the suspension of many old mines, which had struggled along in hope of better times, and stopped nearly all further developments in new localities. To show how general the suspension was, of the 200 mines and ore localities given in the list in the report of the Geological Survey for 1874, only 30 kept in operation throughout the whole period of depression. Ores low in phosphorus and suitable for the manufacture of Bessemer steel, found sale at low prices. Rich ores also met with a steady demand. Others failed to sell at

any remunerative price. The gradual decline in the production of our mines appears in the following statistics the several years from that of 1873 onward:

In 1873	the product	was	665,000	tons.
" 1874	"	"	525,000	"
" 1875	"	"	390,000	"
" 1878	"	"	410,000	"

No attempts were made, either in 1876 or in 1877, to collect the statistics, but from a careful survey of the field, and from estimates by well-informed observers, the aggregate for 1876 was found to be considerably below that of 1875. And the lowest point in the scale of production was reached in the years 1876 and 1877. The next year witnessed a slight increase. While there was no buoyancy in the market the demand was steady and the mines had attained to a minimum in the cost of working. Such was the condition of our iron mining industry at the beginning of the past season, and when the business revival began to manifest itself in the rise in the price of iron. The rapid growth of prices and the increasing demands of the market during the late summer and autumn, were soon felt in the mines. The companies at work sought additional help, and soon began to increase their output of ore. Wages advanced slowly, and labor found a ready market. The greater demand for ore started up many of the old mines and gave a new impetus to the work of prospecting and exploration. The general result is already well known to the public, but it can hardly be fully appreciated outside of the iron ore district. There is an active inquiry about mining localities, such that it cannot be at once answered.

Wages are 35 per cent. above that of 1876 and 1877, and there is a demand for additional labor, notwithstanding the very general introduction of labor-saving appliances and machinery. And men are returning from the West and from the coal mines to their old homes. The working forces have in many places been doubled and even trebled. And the monthly production of the mines during the past few months is probably three times that of the early part of the year. The increased production appears in the sum total of all the mines of the State. This aggregate amounts to 488,028 tons, or 78,000 tons more than in 1878. The increased activity is apparent in the accompanying details of localities. Nearly all of our larger mines are either

working or are being re-opened and put in working condition. And many of the places, which can hardly be called *mines*, are being examined and tested as to their capabilities.

It is highly probable that all of them, which can be profitably worked, will be in operation in 1880, and that the production of the iron mines of the State for that year will be equal to, if not greater than that of 1873.

At the commencement of this new era in the history of our mines, it has been deemed opportune and desirable to report on the condition of the iron-mining industry of the State. The subject is one of importance to our own citizens generally, and of special interest to those in any way engaged in the manufacture of iron, and in the mining of iron ore. The labor of collecting material for this report has been difficult on account of the activity causing constant changes, so that scarcely any two consecutive days would exhibit like conditions. Again, many of the mines were not in a condition favorable for examination. Some were in process of being unwatered, others were in different stages of preparation for working. The greater part of the district has been traversed, and by personal examination supplemented by information from reliable correspondents, those details have been gathered and here given, which show the present condition of the mines. An attempt has been made to get the names of owners and lessees, and the dates of working, but there are many cases in which it was not easy to ascertain these facts. The prominent geological features of the newer localities have been briefly noted, as also the peculiarities of the ores. Where mines have been described in previous reports of the survey, the references have been given and such notes have been added here as to supplement the former descriptions. Of the older and well-known mines very little is said, excepting the facts as to working. In short, this report may be regarded as supplementary to those of previous years. The following list of mines and localities where ore has been found in workable quantity precedes their descriptions. This list includes nearly 300 numbers, or what may be termed mines and ore openings. The list in the report of 1873 had about 200. The increase in the number is due in part to a new mode of counting, whereby such groups as Oxford Furnace, Irondale and Ringwood are resolved into individual mines, and in part to new localities. The number of the latter, which were not mentioned

in the report for 1873, is not large, as an inspection of the detailed descriptions will show. The arrangement in the list conforms to the division of the Highland Range of Azoic Rocks into four parallel belts, known as the Ramapo, Passaic, Musconetcong and Pequest. This division was made in 1873, and the boundaries as then described are here reprinted. The arrangement in these four belts is convenient for reference, although a provisional one, and one which may be superseded by the results of a more detailed survey of the district.

1. RAMAPO BELT.

This belt begins near Peapack, in Somerset county, and extends on in a northeast direction by Pompton to the State line, and in New York, to and beyond the Hudson river. It is about 2 miles wide at the southwest, and at the New York line its width is 5 miles. Mine Mountain, Trowbridge Mountain, the low mountains between Denville and Boonton, the mountain extending from Boonton to Pompton, and the Ramapo Mountain, are all in this belt. Its southeast border is defined by its meeting the red sandstones and conglomerates of the Triassic Formation. Its northwest border is marked by a characteristic white, crystalline limestone, containing serpentine, in grains, in large masses and in fibrous forms known as chrysotile. There are outcrops of this limestone near Mendham, at Turkey Mountain, north of Montville, near Wynokie, near Monks, and at the old Blue Mine, Ringwood.

2. PASSAIC BELT.

The Passaic Belt is the next belt to the northwest, and the line just described is its southeast boundary. It begins at Clinton, in Hunterdon county, at the southwest. Its breadth is nearly uniform, and is about 5 miles. It is bounded by the red sandstone and conglomerate of the Triassic Age from Lebanon to Peapack. Nearer Clinton the magnesian limestone adjoins it on the southeast and south. The northwest border is marked by a continuous valley. This valley begins at the Spruce run, north of Clinton, where its first eastern branch comes in, and follows up the valley of that branch, and over into German Valley. Thence the Berkshire, Longwood and West Milford Valleys are the parts of this long depression. No crystalline

limestone has been found in this belt, but it is distinguished by its rich mines of iron ore.

3. MUSCONETCONG BELT.

The valley above described, as far as it goes southwest, is the southeast boundary of this belt. From the Spruce run to the Delaware river it is bordered by the newer limestones and sandstones. The northwestern boundary is marked, as it runs from the Delaware, by Lower Harmony, up Harker's Hollow, and over the mountainous divide near Mount No More to Oxford Furnace; thence up the valley of the Pequest to Vienna, and then up Bacon creek to Warrenville and Alamuche; along the east foot of Allamuchy Mountain and east of the Cranberry reservoir and the Roseville iron mine to the high dividing ridge between the streams running into the Musconetcong and those running into the Wallkill; from this divide it descends into the valley of the Wallkill and follows along the east border of that valley by Franklin, Hamburg and Vernon to the New York line. Musconetcong, Pohatcong, Schooley's, Hamburg, Wawayanda and other mountain ridges are in this belt. It ends near Newburgh, in New York. It is 6 to 8 miles wide, including several long valleys of magnesian limestone. No crystalline limestone has been found in it, in which respect it differs from the belt next adjoining it on the west.

4. PEQUEST BELT.

In the Pequest belt are included all the Azoic rocks northwest of the boundary line just described. It extends across the State from the Delaware to the New York line. Its northwestern edge is overlaid by Paleozoic rocks. Marble, Scott's, Jenny Jump and Pochuck Mountains are in it. Its greatest breadth is about 3 miles. Crystalline limestone is very abundant in this belt. And it is also characterized by its rich zinc mines, and by its iron ores containing manganese.

The order of description in the belts is from southwest to northeast, and according to the political subdivisions of townships and counties. The townships have been given as far as it was possible to do so. In a number of cases the veins of a mine cross these political boundaries. The locations of the working shafts have determined the township in these instances.

The list of mines is believed to be complete. There may be *localities* where openings have been made years ago, which are not included in it. And the recent impetus to prospecting throughout the whole district is so great that some new openings may have been omitted.

The description of the hematites and limonites follows that of the magnetic ores. And the order of arrangement is from southwest to northeast, beginning at the southeast and proceeding towards the northwest.

RAMAPO BELT.

Mines.—Bernardsville, Janes, Connet, Beers, Taylor, Cole farm, Kahart, Lanagan, De Bow, Jackson, Ryerson's De Bow, Beam, Brown, Kanouse, Butler.

Bernardsville, Bernards Township, Somerset County.—There have not been any further developments at these localities since the report of 1874.

Janes Mine, Bernards Township, Somerset County.—This mine has not been worked in many years.

Connet Mine, Mendham Township, Morris County.—The Connet Mine has been idle for three or four years.

Beers' Mine, Hanover Township, Morris County.—The Report for 1878 contained an analysis of ore from the farm of John H. Beers, near Morris Plains. According to recent information from the owner, the place is leased to Judge Wood, of Dover, and two additional openings have been made. And altogether there have been thirty tons of ore mined and shipped to Rockaway, where it has been used in the Wilson Furnace. No regular vein has been struck. The deepest shaft is down 25 feet.

Taylor Mine, Montville Township, Morris County.—This mine has not been worked for several years.

Cole Farm, Montville Township, Morris County.—The openings on the Cole farm and the indications were described in the Report for 1874. Little work has been done since that time.

Kahart Mine, Pequannock Township, Morris County.—The Kahart mine stopped in 1874. It was re-opened last fall and worked until very recently. The extent of the late mining operations in it were not learned.

Lanagan Mine, Pequannock Township, Morris County.—This mine has not been worked since 1874.

De Bow Mine, Pequannock Township, Morris County.—This mine has not been worked since 1874.

Jackson, or Pompton Mine, Pequannock Township, Morris County.—This mine has not been worked since 1874.

Ryerson's De Bow Mine, Pequannock Township, Morris County.—Mining operations were stopped at this mine in 1874. There is a strong probability that it will be soon re-opened.

Beam Lot, Pompton Township, Passaic County.—An old iron-ore locality on the Beam lot, about 2 miles north-northeast of Bloomingdale, was re-opened in 1875 by a New York company. Some rich ore was mined from a shaft about 20 feet deep. The vein was said to be 4 or 5 feet wide. The place was abandoned shortly after the re-opening, in 1875.

Brown Mine, Pompton Township, Passaic County.—No work has been done here since the winter of 1874–75. A notice of it appeared in the Report for 1874.

Kanouse Mine, Pompton Township, Passaic County.—The old Kanouse Mine, northeast of the Brown openings, has been idle since 1875.

Butler Mine, Hohokus Township, Bergen County.—This mine is on Ramapo Mountain, 2 miles south of Ramapo Station. There has been nothing done in the way of mining here since 1874. During the summer of 1879 some surface work was done, and three veins were opened by R. F. Galloway, of Sufferns, N. Y. They are from 3 to 10 feet wide. About 50 tons of ore were taken out.

PASSAIC BELT.

Mines in Hunterdon County.—Large, High Bridge, Silverthorn, Sharp, Emery, Old Furnace, Cokesburgh, Fisher, or Fox Hill, Sutton, Pottersville, Bartles.

Morris County, Chester Township.—Pottersville (northeast), Rarick, Langdon, Pitney, Budd & Woodhull, Topping, Samson, Hotel, Collis, Creamer, Swayze, Cooper, Hacklebarney, Gulick, Creager, Hedges, Dickerson, Creamer, De Camp, Leake, Daniel Horton, Barnes.

Randolph Township.—Henderson, George, David Horton, De Hart, Lawrence, Dalrymple, Trowbridge, Solomon Dalrymple, Cooper,

Munson, Lewis, Combs, Van Doren, Bryant, Connor Fowland, Charles King, King, McFarland, Evers, Brotherton, Byram, Baker, Millon, Randall Hill, Jackson Hill, Canfield's Phosphatic Iron, Black Hills, Dickerson, Canfield, Baker, Spring, Sullivan, Corwin, Stirling, Hubbard, North River, Harvey, Hurd, Orchard, Erb, Scrub Oak.

Rockaway Township.—Johnson Hill, Hoff, Dolan, Washington Forge, Mount Pleasant, Baker, Richards, Allen, Teabo, Mount Hope, Hickory Hill, Swedes, Sigler, White Meadow, Beach, Hibernia, Beach Glen, Tichenor, Righter, Meriden, Cobb, Splitrock Pond, Greenville, Chester Iron Company's Mine, Green Pond, Howell, Kitchell, Charlotteburgh.

Pequannock Township.—Botts, De Camp, Decker, Gould, Stony Brook, or Pike's Peak.

Passaic County.—Vreeland, Wynokie, Tellington, Rheinsmith, Monks, Board, Hard, Little Blue, Little Red, Blue, Bush, Cannon, St. George, Cook, Miller, Cooper, Peters, Hope, Winslow, Ward.

Large's Mine, Clinton Township, Hunterdon County.—The mine opened by the late John K. Large, on the Hoffman place, west of Round Valley, has not been worked since 1875. The veins were narrow. Several hundred tons of ore were mined.

High Bridge Mines, High Bridge Township, Hunterdon County.—These old and well-known mines have been described in previous reports of the survey. The line of shoots is held by two owners, John Kane on the west and the Thomas Iron Company on the east. The property line runs a northeasterly course, and cuts the vein in such a manner as to give the upper shoots towards the southwest to the one, and the deeper portion of the ore as well as the northeastern end of the vein to the other. The former, or Kane property, was worked until June of this year by the late John K. Large, of White House. The Thomas Iron Company stopped work last April, and the mine is partly filled with water. Llewellyn James, the superintendent of the company, is raising a little ore from above the water line.

The several openings, extending from the public road—northeastward to the end of the hill—and to the Chester railroad, are at least a half a mile in length. And the deepest of them are down 200 feet below the surface of the hill. They show very plainly the shoot structure and a series of shoots, which run more towards the east than

the general trend of the ore, *i. e.*, they are oblique to the course of the *vein*. The pitch is towards the east—northeast—and is steeper at the northeast end of the hill than at the southwest. The workings of Mr. Large discovered three and four parallel shoots, side by side, separated by thin rock masses. As to details: the deepest shaft on the Large lease is near the road, and is 105 feet vertical, then inclined, on the slope of the foot-wall. A few rods north—northwest of that one, and at the south end of a large shoot—there was a shaft 70 feet deep. Parallel to this shoot were three others, one of which measured 55 feet across. It was worked by both lessees. The width of these shoots nowhere exceeded 100 feet, and the deeper workings stop at their lower edges. It is said that no one of them pinched out, but became thin—1 to 2 feet. The *pinches* were due to the *rolling* of the foot-wall, becoming flat, and so cutting out the vein. A great deal of ore was found near the surface and worked in open pits. Whenever the property line was reached, the working was transferred to the Thomas Iron Company. In their mining operations the shoot structure with its accompanying pinches has been found to continue northeast, and as deep as they have worked. On account of it the mine has presented widely differing prospects, but a judicious system of working, recognizing the peculiarities of structure, has succeeded in finding new shoots, and in making the mine a productive and valuable one. In some of the older open pits on the north end of the hill the wall rocks show the pitch very distinctly. It is on an average at an angle of 60° towards the northeast. The dip is, in places, almost vertical, or at a very high angle towards the southeast. There is a tunnel at this end of the hill running into an old open working, but the mining went 100 feet below its level, so that it has been of no use. Had it started in lower down on the hill, it would have been deep enough to drain the deepest workings, and it need not to have been 100 feet longer. Trial pits on the north foot of the hill have failed to strike ore. It is possible that the shoots pitch down so much as to get beyond the depth of any ordinary trial shafts. The annual product of these mines has been large, and the greater part of it has been used at the works of the Thomas Iron Company, at Hokendaqua, Penn.

Silverthorn, or Kane Openings.—The above name is given to openings on the southern slope of a hill, near the school-house, one mile

northwest of High Bridge. The property is owned by John Kane, of Elizabeth. The hill has been tested by several holes, of which the deepest is not over 15 feet. In this one there appears to be a vein several feet wide, and dipping to the southeast. The ore contains pyrite and hornblende. The openings are not deep enough to show the extent or probable size of the vein. The attraction about the pits is positive, and amounts to 10–40 degrees. Northward it is negative.

The searches here were made several years ago, and no work has been done since that time. The indications and the location so near to railroad transportation are such as to suggest further exploration. It was not mentioned in the Report for 1868 nor in that of 1873.

Sharp's Mine.—A little mining was done on the farm of Morris Sharp, 1½ miles east of High Bridge, previous to the panic of 1873, and at intervals up to last spring. One shaft is 50 feet deep. There are several holes. The ore was said to be of good quality, but the excessive amount of water made the mining expensive. The engine-house is standing, but the engine has been removed.

Emery Farm.—On the farm of Geo. L. and A. Emery, 1 mile east-northeast of High Bridge, there are two openings on ore. They are about one-quarter mile northeast of the farm-house, and about 200 feet apart in a northeast and southwest line. The northeast one is 25 feet deep. Here a vein of ore 2 feet thick was struck. It dips to the southeast. The ore contains some pyrite and some hornblende. Over 200 tons of it were shipped. The southwest opening is shallow, and 12 to 15 feet wide. The material here is a reddish, garnetiferous rock, containing some magnetite. Some of it was sent to Uhlerstown, Pa., where it was used in blast furnace. It may have answered as a flux. As an ore it is very lean. The indications are that there is a large body of it. Some work was done here in the autumn of 1878.

Old Furnace Mine, Tewksbury Township.—This mine has been idle since the last notice of it—in the Report for 1873.

Cokesburgh Mine, Tewksbury Township.—The Cokesburgh mine has been idle for several years.

Fisher, or Fox Hills Mine, Tewksbury Township.—This locality was opened in November of 1873. A notice of it was in the report for that year. A sample of the ore received from the lessee, John D.

Mills, M. D., of Rockaway, was analyzed, and the analysis published in last year's report. When visited in October, the main shaft was down 25 feet. It is west of the first openings, which were made in 1873. There is much water in the shaft, but the pumping is conveniently done by water power working a 3 inch pump. The ore on the bank contained a little pyrite and some hornblende. It is very hard. According to the analysis of last year it contains 57.5 per cent. of iron, .59 of sulphur, and only .04 of phosphorous. No ore has been sent away. The nearest railroad station is at Califon, 4 miles distant.

Sutton Farm, Tewksbury Township.—On the farm of George B. Sutton, adjoining the Fisher place on the southwest, two shafts have been sunk in searching for ore. The deepest is 22 feet deep. About 50 tons of ore were sent away from here to Allentown, Pa. These openings are in a southwest line from Mills' shaft, and about 100 yards from it.

Pottersville Openings.—Nothing further is known of these openings than the description as given in the Report in 1873.

Bartles' Openings.—Of these openings, also, there is no further information.

Openings Northeast of Pottersville, in Chester Township, Morris County.—The locality remains one of exploration rather than one of supplying ore.

Rarick Farm.—This locality is not worked.

Langdon's Openings.—A line of attraction 1000 feet long, and several trial pits and ore, are reported on a farm owned by Langdon & Nichols, in Washington township, Morris county.

Pitney Farm.—This property is 1½ miles from Hacklebarney, down the valley of Black river. It is being explored by Cooper, Hewitt & Co. It was not visited. Some of the red surface ore has been shipped from Hacklebarney by the High Bridge railroad.

Budd and Woodhull Mines.—These mines have been idle for several years.

Topping Farm.—A considerable amount of ore was mined here by the Union Iron Company, previous to the panic, but the openings have been filled up.

Samson Mine.—This mine is now idle.

Hotel Property.—This property has not been developed into a mine.

Collis Farm.—Like the last-named place, this one is yet to be further tested.

Creamer Farm.—The line of ore on the Creamer farm has not been opened to any further extent.

Swayze Mine.—The Swayze Mine is held by the Chester Iron Company. It is idle, but is to be started as soon as miners can be found.

Cooper Farm.—A line of attraction is traceable on the property of the late Gen. Nathan A. Cooper, from the Swayze Mine. According to report the place is about to be tested and the vein opened.

Hacklebarney Mines.—The uninterrupted and extensive mining at Hacklebarney, since the Report of 1873, has developed such an extent of ore on both sides of the Black river, that it seems proper to designate the several openings as mines rather than parts of one mine. Northeast of the river there are five veins worked, although it is not altogether certain that there are not more, as in most of the workings no walls are found behind which there is no more ore. Near the river there are three veins quite close together, so that the removal of the intervening rock may be necessary as the drifting progresses in them. The working in these open cuts and drifts has not yet gone much below the level of the river. The amount of ore in the hill above the water level makes the mining easy and economical. To the northeast and on the hill the vein of the main open cut is cut by a tunnel which runs into the hill a distance of 300 feet from the railroad track, along the western foot of the hill. Beyond this point, and further northeast, there are several openings. Some of them are in the old open pits. To the east of these pits there are two whim shafts on two shoots of ore, which appear to be southeast of the lines of strike of the open cuts at the river. They are 35 to 40 feet deep. The most easterly opening on the property is nearly a half mile from the river, measured on the course of the veins.

On the southwest of the Black river the opening known as the Coal House Cut is about 150 feet long and 45 feet deep, and the breadth of ore in it is 40 feet. But the surface indications and diggings show the existence of veins, both to the east and to the west of the walls of the cut. The hoisting and pumping from this cut are done by water power furnished by the river. The same stream is used to compress air for a drill which is employed in this cut.

On the hill southwest of the Coal House Cut four openings are being worked. Two of these appear to be on the same vein. The stratification in them is very distinct, and the dip is 70° to the southeast.

The strike is slightly undulating. In general, the strike of the ore on the southwest of the river is more north and south than that of the veins on the east of the stream. The ore in these western openings has a schistose structure, occasioned by the greenish mica occurring in parallel and thin laminæ and layers with the magnetite. The same mineral occurs in the ore of the openings east of the river, but not to the same extent. The laminated structure is, however, common to the ore from all parts of the property. The layers of mica are sometimes one-quarter to one-half inch thick, but more commonly they are thinner. The magnetite ranges from one-half inch upwards. Pyrite is common to all the blue ore. In the surface specimens it is not seen, having disappeared through changes induced by atmospheric agencies.

The following analyses for iron, sulphur and phosphorus, were made last winter. The samples were carefully selected, and are good averages of the several parts of the mines.

NUMBER OF SAMPLE.	1	2	3	4
Metallic Iron	55.72	57.46	53.75	57.68
Sulphur	3.29	3.42	3.33	2.66
Phosphorus	0.032	0.033	0.036	0.025

1. Southwest Hill, Open Cut.
2. Andrews' Cut.
3. Birch Tree Opening.
4. Wiggins' Open Cut.

The agreement between Nos. 1, 2 and 3 are noticeable. No. 4 is richer and carries less sulphur, and very little phosphorus.

The low percentage of phosphorus in the greater part of the Hacklebarney ores admits of its use in the manufacture of Bessemer pig metal. Owing to this character it has found sale, and the mines have been worked steadily since our last Report in 1873. The completion of the branch of the High Bridge railroad to the mines has facilitated greatly the work of transportation. The extent of the openings is such as to give employment to a large force of men, and at a number of points, and these mines are capable of producing annually a much greater amount than at present mined. The product for the year 1879 was 21,548 tons. They are now yielding 3000 tons of ore a month, and the company hopes soon to make the monthly

output 4000 tons. The Chester Iron Company owns and works the mines.

Gulick Mine.—The Gulick Mine was worked by W. J. Taylor & Co. until quite recently, when it reverted to the original owner.

Creager Mine.—This place has not been worked lately.

Hedges Mine.—This mine yielded a large amount of ore, which was worked up in the Chester furnace. It is now idle.

Dickerson Farm.—The developments on this farm were discontinued several years ago.

Creamer Farm.—The Creamer farm lines have not been opened into an ore-producing mine.

De Camp Mine.—No work has been done here since 1874.

Leake Mine.—This mine has been idle since 1869.

Daniel Horton Mine.—This mine has been idle since the panic began.

Barnes Mine.—No work has been done here in several years.

Henderson Mine, Randolph Township.—This mine is idle.

George Mine, or Logan Mine.—The Logan Mine is owned by A. Pardee. It was worked for the Musconetcong Iron Works until it stopped, in October, 1873.

David Horton Mine.—This mine has been idle since the beginning of the hard times.

De Hart Mine.—The De Hart and Lawrence, or Gordon Mine, have been leased recently by the Reading Iron Company. They are now being re-opened.

Lawrence Mine.—The Lawrence Mine was worked up to 1878. There are three shafts, one of which is 110 feet deep. Between the middle and the southwest shaft there is an offset in the vein; and the shoots are said to pitch towards the southwest. The line of vein on the Lawrence lot is short, and the northeast shaft is close to the Dalrymple property. John Moyse is superintendent of the mining operations here.

Dalrymple Mine, or Carbon Mine.—This mine was worked by the Carbon Iron Company to 1876. The property is owned by Lawrence Dalrymple. The lease has been sold recently to the Crane Iron Company. And this company has been at work three months re-opening the mine. It was described in the Report for 1873. Since that publication a new shaft (known as No. 9) has been sunk near the

line of the Lawrence property. It is about 70 feet deep on the dip of the vein, which is at an angle of 70° towards the southeast. From this slope there are working drifts both to the east and west. The ore from it is fine-grained and rich, and has a tendency to a prismatic structure. Of the old shafts, Nos. 5 and 6 are said to be down nearly 300 feet. West of the latter the vein is faulted towards the foot wall corresponding to the offset in the Lawrence Mine. The ore is carted to Vanatta station and shipped to the company's furnaces at Catasauqua.

Trowbridge Mine.—This mine has been idle for several years.

Solomon Dalrymple Mine.—This mine has been idle for severral years.

Cooper Mine.—This mine has been idle for several years.

Munson's Mine.—This mine has been idle for several years.

Lewis Mine, or Herrick Mine.—This mine has been idle for several years.

Combs Mine.—From E. Canfield, of Ironia, who is now working this mine, the following notes were received: There are 2 shafts, 1 of which is over 100 feet deep, and the other between 50 and 60 feet deep. The latter is the working shaft. The vein has been opened 500 to 600 feet in length. It is about 10 feet wide. The ore contains feldspar and is lean, yielding on an average 40 per cent. of metal. The walls are hornblendic rock. The ore is carted 2½ miles, to Ironia, and is sent to the Lackawanna Coal and Iron Company's furnace at Franklin, where it is used with Spanish and other ores for making Bessemer pig.

Van Doren Opening.—The place has not been worked since 1873.

Bryant Mine.—This mine is idle.

Connor Fowland Mine.—This mine is idle.

Charles King Mine.—This mine has been idle for about fifteen years.

King Mine.—The King Mine, on the property of the Dickerson and Succasunny Mining Company, is worked by A. Pardee.

McFarland Mine.—This mine is idle.

Evers Mine.—This mine is idle.

Brotherton Mine.—The Brotherton Mine has been lately re-opened by the Andover Iron Company. It is yielding now about 650 tons a month. There are 2 small veins which are a few feet apart. The mine is 200 feet deep.

Byram Mine.—The Byram and Byram-Russell Mines continue to be steadily worked by the Andover Iron Company. At present ore is being mined from the most southerly shaft, near the road. The old mine slope is 900 feet long. The vein averages 6 to 7 feet in width. In consequence of the greater volume of water at the bottom of the mine, it has been necessary to put in larger pumps. Formerly the most of this water was held at 450 feet and raised from that depth. A narrow gauge railway runs from the mine to Ferromont, carrying the ore to the High Bridge railroad, whence it is sent to the company's furnaces at Phillipsburg.

Mellen Mine.—The work of re-opening this mine has been very lately begun by the Boonton Iron Works, under the superintendence of Robert F. Oram, agent of the company. The ore is for the supply of the company's furnaces.

Randall Hill Mine.—The Randall Hill Mine is steadily worked by the Crane Iron Company. The ore is used at Catasauqua, Pa.

Jackson Hill Mine.—The mining operations at this mine stopped several years ago. The buildings and machinery have been removed. It is reported that the vein had gone beyond the property line, towards the east, and that the workings had reached that boundary.

Canfield Phosphatic Iron Ore.—The openings on this vein of mixed magnetite and apatite have not been continued since the Report of 1872; and there have not been any attempts to utilize the ore or phosphate.

Black Hills Mine.—This name is given to the veins which are worked on the hill south of Dickerson Mine, and on the property of the Dickerson Mining Company. The workings are in charge of John M. Barnes, and the ore is sent to the furnace of A. Pardee & Co., at Secaucus. There are four small veins, two of which are worked by one slope. At no point are the workings down 100 feet. The ore is remarkable for its low percentage of phosphorus and the presence of white quartz. It is valuable for mixing with the rich Spanish and other foreign ores for the manufacture of Bessemer metal.

Dickerson Mine.—This old and well-known mine continues to be steadily worked and is now producing at the rate of 2800 tons a month. Since the Report of 1873, at which time it was held by the Allentown Iron Company, it has been leased to A. Pardee, and is worked under the superintendence of E. S. Moffatt, M. E., of Stan-

hope. A new slope was completed in November, 1878. It facilitates greatly the raising of the ore, and increases the capacity of the mine. It is about 900 feet in length, and the northeast heading is now northeast of the old Dickerson mansion. The big vein and the side vein on the hanging-wall are worked. The larger part of the ore goes to the Musconetcong Iron Works, at Stanhope. It commands a ready sale on account of its richness, and brings a large royalty to the owners, the Dickerson Succasunny Mining Company. The product of the mine in 1879 was 27,251 tons.

Canfield Mine.—The Canfield Mine also belongs to the Dickerson Mining Company. It was worked several years by E. Canfield. It is idle.

Baker Mine.—The mine of this name, northeast of the Byram Mine, has not been worked for several years.

The Baker Mine, until recently owned by Waterman & Scranton, is on the same property, but further to the west. This mine is now worked under the superintendence of A. Beemer, of Dover. It is 110 feet deep, and is opened on the vein a length of 225 feet. The ore varies from 2 and 3 feet to 12 and 20 feet in breadth, and is, on the average, 8 or 9 feet. The ore is rather lean, containing considerable quartz and feldspar. The percentages of sulphur and phosphorus are low, so that it is said to be suitable for Bessemer metal.

Irondale Mines.—The group of mines owned by the New Jersey Iron Mining Company, and commonly known as the Irondale Mines, includes the following:

Spring Mine, Sullivan, Corwin, Stirling, Hubbard, North River, Harvey, Hurd. Of these mines all are idle excepting the Stirling and the Hurd, both of which are leased to the Thomas Iron Company.

The Stirling Mine shoot has been followed about 1500 feet on a gentle pitch to the northeast. The average thickness of the ore is 6 feet. And the height of the shoot is now 90 feet. The mine is producing about 1200 tons per month.

The Hurd Mine was opened in 1872 by the Thomas Iron Company. In 1874 a subterranean stream of water prevented working it to its full capacity, and finally led to a stoppage. Similar difficulty was met with in the Harvey and Orchard Mines. To relieve these mines of the excessive amount of water, the Orchard and Irondale Adit was projected. The following description of this work is by L. C. Bier-

wirth, Mining Engineer and Agent of the New Jersey Iron Mining Company.

The Orchard and Irondale Adit was commenced in April, 1877, by the New Jersey Iron Mining Company, the Thomas Iron Company and the trustees of the estate of J. C. Lord, with a view to draining the Orchard and Hurd Mines at Port Oram, both of which at the time were idle and full of water. In the Orchard Mine it had required 2 18-inch, 1 14-inch, and 1 6-inch pump, with a 4 feet 10-inch stroke, and running 8 strokes per minute to keep the water; and at the Hurd Mine it had broken in in the spring of 1874 with such force as to drown the pumps.

The mouth of the discharging ditch connecting with the adit was located at a point on the west bank of Rockaway river, 200 feet below the "Three-Span" Bridge of the D., L. & W. R. R., and the ditch and main adit have been carried up on the south side of the railroad a total distance of 3667 feet, the ditch being 983 feet and the adit 2684 feet long and 5 feet wide, with a grade of about three-quarters of an inch to 100 feet. The ground encountered has generally been coarse gravel, with numerous boulders and occasional beds of quicksand, but no rock in place was met in the entire distance. The drainage to the east and northwest, after the adit had been driven some 1000 feet from the mouth of the ditch, became very marked, and reached to a great distance. The work was carried on with 3 8-hour shifts, and the greatest distance driven in any month was 184 feet in January, 1878. After the adit had been driven the above-named distance of 3667 feet, which had been accomplished in April, 1879, the breast was still 420 feet distant from the Orchard pump shaft; but owing to the porosity of the gravel, the water had been lowered in that shaft from 40 feet below the surface, at which level it stood before the adit was commenced, to a depth of 64 feet 4 inches from the surface, being within 10 feet of the point at which the adit was calculated to reach the shaft. The agent of Mr. Lord's estate, Mr. Robert F. Oram, determined to try the quantity of water which the mine still made, and on starting to pump it out, found that a 14-inch pump running 6 strokes per minute was more than sufficient to keep the water.

The effect of the adit upon the Hurd Mine, which was still 1530 feet distant, had not been so great, but still was sufficiently marked as

to induce the Thomas Iron Company to put up powerful pumps and take the water out in the summer of 1878, when the water in the Hurd shaft had been upward about 20 feet. This season a branch of the main adit was driven towards the Hurd Mine, a distance of 653 feet, from the diverging shaft at the end of the main adit. When within 110 feet of completing this distance, a bed of quicksand was encountered, causing much trouble and delay; but as soon as it had been cut through, the water in the Hurd Mine was very greatly decreased, so much so that whilst it had previously amounted to 300 gallons per minute, it is now only 80 gallons, making a saving of 50 tons of coal per month. The work on the adit has been suspended for the present. When completed to the Hurd Mine, it will unwater that mine at a depth of 94 feet from the surface of the old shaft.

The velocity of the stream in the main adit is 42.8 feet per minute and its average depth 14 inches, with a width of 4 feet 8 inches inside of the timbering.

Orchard Mine.—Work was resumed in the Orchard Mine February, 1879. The adit carried away the surface water, so that it was found that 1 10-inch pump running at 7 strokes a minute, would raise the water, whereas, before there were 2 18-inch pumps, 1 14-inch, and 1 10-inch pump, with a stroke of 4 feet 10 inches, and working 9 strokes per minute. The mine is now about 500 feet deep. It is worked by the trustees of the estate of J. Couper Lord.

Erb Mine.—The Erb Mine belongs to the Andover Iron Company. It has been idle for 10 years.

Scrub Oak Mine.—This mine also is owned by the Andover Iron Company. The vein is wide, and has been opened for over 1000 feet in length. The ore is lean.

Johnson Hill Mine.—The Johnson Hill Mine is the southwest extension of the Huff veins. The hill is 100 feet approximately above the level of the road, and the northeast shaft of the Huff Mine. It is not now worked.

Huff Mine.—The Huff Mine was idle from 1874 until November of the present year, when work was resumed by the lessees—the Chester Iron Company. The openings indicate a succession of shoots, which pitch to the northeast. The deepest shaft is at the side of the public road, and is 114 feet deep. The pumping here takes the water from the other openings above it, on the hillside. The ore of these

shoots contains some mica, which gives it a laminated structure. But the bottom ore is more solid. The open cuts higher up the hill show alternations of ore and rock, and do not reach a hanging-wall. To the northwest of the main line of openings there is what is known as the Hard Vein. The ore in it is lean and hard, containing quartz. The mine is now yielding at the rate of 1000 tons per month.

Dolan Mine.—The Dolan Mine is on the mountain northeast of Mount Pleasant. It has not been worked to any extent; and it is now idle.

Washington Forge Mine, Rockaway Township, Morris County.—The adit to the Orchard Mine appears to have taken off much of the surface water, which was formerly so troublesome at this mine; and the work of pumping out the water and re-opening the mine has been begun by John Brown, of Easton, Pa.

Mount Pleasant Mine.—The Mount Pleasant Mine has been going steadily through the dull times. As heretofore, the greater amount of ore is got in the eastern part of the mine, and very little is done in the west mine. The depth of the east mine is 600 feet. The thickness of the ore is found to be greater at the bottom than it was at a less depth. Since the stoppage of the furnaces at Boonton the ore has been sold. The owners are the trustees of J. Couper Lord's estate, and the mine is in charge of Robert F. Oram, of Dover. Joseph Richards is superintendent at the mine.

Baker Mine.—The Baker Mine was worked by the Allentown Iron Company until in 1877. At the bottom the vein *pinched* almost out. Borings 100 feet downwards and in the plane of the dip failed to discover any workable body of ore, and it was abandoned.

Richards Mine.—The Thomas Iron Company is working the Richards Mine. The southeastern vein is the larger of the two veins, and from this one comes the most of the ore which is raised from the mine. The ore is sent to Hokendauqua, Pa.

Allen Mine.—The Allen Mine is owned by the New Jersey Iron Mining Company, and is leased by the Andover Iron Company. The shoots are found to be the largest to the northeast. Towards the southwest there is more rock mixed with the ore between well-defined walls. One vein is worked. A tunnel 60 feet long runs into it. The deepest parts of the mine are 250 feet below its level. From this vein a tunnel was driven 300 feet across the strata, in search for

the big vein of Mount Hope Mines. No ore was found. Mr. George, the agent of the Andover Iron Company, is having a drift cut in the eastern vein of the Richards Mine towards the Allen line. It will be 275 feet long to the property line. At the starting point the shoot in the Richards Mine is large, and he hopes to follow the Richards shoot on to the Allen property, and so find an eastern vein. The results of these explorations will be of much interest, and important to all engaged in mining iron ore as well as to geological science. The ore from this mine is worked at Phillipsburg.

Teabo Mine.—The Teabo Mine continues to be worked by the Glendon Iron Company. The explorations in search for the Big or Taylor Vein, which has been supposed to extend from Mount Hope across on to this property, have failed thus far to discover it. The mine is yielding steadily a large amount of rich ore. The general features of the mine are about the same as when last visited.

Mount Hope Mines.—The Mount Hope and Hickory Hill Mines are owned and worked by the Lackawanna Iron and Coal Company. During the financial depression the Hickory Hill Mines were idle, as also the Taylor or Tunnel Mine. The Elizabeth Vein was the only one which was worked steadily. The mines on Hickory Hill are still full of water. The Taylor mine is being put in order for work. The aggregate production of the mines has been about 2400 tons a month, but it will be doubled and trebled as soon as the arrangements for increased mining operations can be made. The ore is sold.

Swedes Mine.—This old and noted mine, belonging to the heirs of J. Couper Lord, has not been in operation since 1875.

Sigler Mine.—This mine is not in operation.

White Meadow Mines.—These mines are not in operation.

Beach Mine.—This mine is not in operation.

Hibernia Mines.—The mine lots, or mines at Hibernia, are beginning at the south end of the hill; Lower Wood, worked by the Andover Iron Company; Glendon, worked by the Glendon Iron Company; Crane, worked by the Glendon Iron Company; De Camp, worked by the Glendon Iron Company; Upper Wood, worked by the Glendon Iron Company; Willis, worked by the Bethlehem Iron Company.

The New Jersey Iron Mining Company owns the Lower Wood, Upper Wood and Willis Lots.

The Lower Wood Mine is worked out to a depth of 250 feet below the Hibernia brook; the sink is about 400 feet deep. There are two shafts and one incline. The latter is 600 feet long. The ore is raised in cars running up the incline. A separate engine works compressor for driving three drills. The company is erecting another to run an additional number of drills. The Rand pattern is used. The working force has been largely increased lately, and Mr. George, agent of the company, reports a monthly product of 4000 tons.

The Glendon Iron Company has been mining a great deal of ore, and preparing for a larger output by the construction of a tunnel, which serves for draining as well as for transportation.

The Bethlehem Iron Company is preparing to resume work in their mine at the northeast end of the hill. The continued productiveness of the Hibernia Mines is exhibited in the tonnage of iron ore, of the Hibernia Mine railroad. This amounted to 99,123 tons in 1879.

Beach Glen Mine.—This mine was not in operation from 1875 to 1879. During the greater part of the year it has been worked under the management of the estate of James Couper Lord, the owners. The ore goes to Boonton. Two veins have here been worked to a depth of 100 to 130 feet throughout a distance of several hundred feet, northeastward from the border of the old Horse pond. A peculiar feature of these veins is their dip towards the northwest. It is very steep, almost vertical. The veins are large. In the eastern there is remarkable alternation of mica and magnetite, constituting a highly laminated structure. A short branch road connects the mine with the Hibernia railroad.

Cobb Mine.—The Cobb Mine on the east side of the Splitrock Pond is now worked for the supply of the Wilson furnace, at Splitrock. It is producing 350 to 400 tons per month.

Splitrock Pond Mine.—In the Report for 1874 there was a short description of the mine at the head of Splitrock Pond. It was worked a little while in 1875. During the past year operations were resumed by Wm. S. De Camp. The surface indications were carefully noted in a magnetic survey of the locality made in 1875. There is a belt of strong attraction on the east side of the Charlotteburgh road, and crossing the same northward towards the pond. It is about 300 feet long, and 100 feet wide at the southwest end, and about 50 feet wide at the northeast end, (near the barn.) At the southwest and

on the western side it is negative. Elsewhere it is positive. Going southwest to the holes near the pond, the attraction is very light. And it does not appear to be continuous with that of the main belt. Northeastward a light attraction is said to be traceable for a half mile, along the line of the Charlotteburgh road.

Two veins have been opened. They are not more than 50 feet apart. The pump shaft in the hanging-wall vein is 60 feet deep. This vein is reported to be 14 feet across from foot-wall to hanging-wall, (as workings have opened it,) with ore in the hanging-wall side. In the foot-wall side of the vein, and for a breadth of 7 feet, there are alternating strings of ore and mica. The foot-wall, or west vein, has been opened so as to show a shoot of rich ore, which is 25 feet high and 8 wide. A drift from the bottom of the shaft to the east vein allows the water to flow into the sink in the latter. The ore raised the past autumn has been shipped to the furnace of A. Pardee & Co., at Secaucus, where it has been worked into Bessemer metal. Analysis of average ore from east vein, made at the Survey Laboratory in 1875, gave:

Metallic Iron	63.399 per cent.
Phosphorus	0.0109 "
Sulphur	0.068 "
Titanium	none.

Greenville Mine.—There have been no further developments at this place since 1873. The locality is one of exploration, and not producing ore.

Chester Iron Company's Mine.—Nothing has been done at this place since the Report of 1873.

Green Pond Mines.—These mines were described in the Reports for 1873 and 1874. Since the latter appeared the failure of the Green Pond Iron Mining Company has necessitated a change in the management. For two years they have been worked under the superintendence of Robert F. Oram, for the creditors of that company, Charles E. Maxwell, trustee. William V. Curtis has charge of the mines. A large amount of ore has been mined, and the existence of large shoots of ore has been demonstrated. The present operations are on the south tract, or Wild lease, and in slopes Nos. 1, 3, 5 and 2, in order, going northeast.

South Tract.—Here the ore has been found close to the surface, on the east or lower side of the road, and not more than 200 feet from

the ledges of conglomerate. In the trial pit south of the road to the mines, the dip of the ore bed is 25° to 30° towards the southeast. The pyrite in the ore undergoes decomposition quickly, causing the ore to fall to pieces after a few months' exposure. In the shafts north of the mine road the vein is quite flat and the ore is pyritous, but rich. It contains less mica and is harder than that of the mines to the northeast. Some of the surface ore would need to be washed. The deepest of these openings on the south tract is 40 feet. There is no water in them. Thus far they indicate a succession of shoots, which may not be in the same vein.

Slope, or Opening, No. 1, is at the border of the swamp. It is the deepest on the property, and is 300 feet long. The ore mass here worked is 70 feet wide and 20 to 25 feet thick. An engine at the head of the slope raises the ore and pumps the water. But there is little water to be raised. Preparations are making to change the track here so as to work down the ore, which crops out at the head of the slope and under the engine-house, and which appears to be the end of a lower shoot. The work here has not advanced far enough to determine any of the dimensions of this newly-opened shoot.

Opening No. 3 is but a few feet north of and above No. 1. This slope is 170 feet long, and the shoot of ore is 60 feet wide, or high, and 20 feet thick.

Slope No. 5 is separated from No. 3 by 2 feet of rock. The Green Pond Iron Mining Company took a large amount of ore from this opening. It is not worked at present.

Slope No. 2 is northeast of the office, and 250 yards from No. 1. The track is 250 feet long, descending at an angle of 30° towards the northeast, on the bottom rock of the shoot. The dip of the foot-wall here is 40° to the southeast. The breast of ore is 20 feet wide, but there appears to be a separate vein, 3 feet thick, on the foot-wall, going back, under the slope. Further opening may prove the rock under the track to be a horse which ends near the present heading. The foot-wall is clean; the hanging-wall is not, but ore and rock mined. Pillars of ore are left to support the latter, so that there is no timbering. And there is no water, except that from rains. The ore is raised in cars by an engine at the head of the slope.

The ore of these several slopes is very uniform in character. All of it contains pyrite, and nearly all of it has to be roasted before

smelting. A greenish mica in it in thin layers, alternating with thicker layers of magnetite, gives it a schistose structure.

The ore is loaded on cars at Slope No. 1, the terminus of the Green Pond railroad, which connects with the New Jersey Midland railway near Charlotteburgh, and is sold to Pennsylvania furnaces. On account of the low percentage of phosphorus, it has been used in making Bessemer steel.

The development of this property has been very interesting to the Geological Survey, as it is one of the more recently opened iron mines, and repeated visits have confirmed the first observed indications of a great extent of ore. It is hoped that under its present skillful and energetic management additional veins will be found, and several large and enduring mines opened.

Howell Tract.—The lot adjoining the property of the Green Pond Company on the north belongs to Monroe Howell. Attraction was observed across it; and 50 to 100 tons of ore have been taken from one trial shaft.

Kitchell Tract.—The Kitchell tract is on the eastern side of the Copperas Mountain, and adjoins the Howell lot on the northeast. Two veins of ore were opened several years ago by five test pits, and a small amount of ore was obtained. It is rather lean, and contains some pyrite, resembling that of the Green Pond mines. The Green Pond railroad runs near the eastern boundary line of the tract.

Charlotteburgh Mines.—The Charlotteburgh Mines belong in part to Martin J. Ryerson.

The Bethlehem Iron Company worked here up to the commencement of the panic. Harry J. Blackwell, of Newfoundland, did some work after the Bethlehem company gave up the lease, and opened two veins on the hanging-wall side of the old mine holes. The mines are now idle. Analyses of these ores were reported in 1878.

Botts Farm.—There is nothing to add to the notice of this place as it was given in the Report for 1873.

De Camp, or Rockaway Valley Mine.—This mine was in operation until shortly before the panic of 1873. It was worked for the Musconetcong Iron Works, at Stanhope, and the total product was large.

Decker Farm.—This locality is idle.

Gould Farm.—This locality is idle.

Stony Brook, or Pike's Peak Mine.—Notices of this mine have

appeared in the Reports for 1868, 1873 and 1876. It possesses some historic interest as having been opened by the London company more than 100 years ago. It was worked a little about 18 years ago by Mr. Ryerson, and last autumn work was resumed. The vein is narrow, 2½ to 3 feet wide, but the ore is rich, and of superior quality. Analysis of a sample from Mr. Ryerson was made in 1876. [See Annual Report for 1876, pp. 54, 55.] The locality is 1 mile from the Charlotteburgh and Splitrock road, and 2 miles southeast of the former place.

Vreeland Farm.—Magnetic ore has been discovered lately on the farm of Thomas B. Vreeland, 1 mile north of Charlotteburgh station, and close under the conglomerate cliffs of the Kanouse Mt. Several holes have been dug, of which the deepest is between 35 and 40 feet deep. The ore is similar to that which is found in the mines at the foot of Copperas Mountain. This new locality shows the existence of a range of ore bodies and mines, in the gneiss rock, close to the Green Pond Mountain conglomerate.

Wynokie Mines.—No work has been done in these mines in many years.

Tellington Mine.—A notice of the Tellington Mine appeared in the Report for 1874. The further developments have been very slight, and the place is not worked.

Rheinsmith Farm.—Like the last-named, the Rheinsmith place has not developed into a producing mine.

Monks Mine.—There is no report of this mine as being worked.

Board Mine.—The mine here stopped before the late depression began.

Ringwood Mines.—The several mines on the Ringwood Tract are the Hard, Little Blue, Little Red, Blue, Bush, Cannon, St. George, Cook, Miller, Cooper, Peters, Hope, Winslow and Ward. They are owned and worked by Cooper, Hewitt & Co.

MUSCONETCONG BELT.

Mines in Hunterdon County, Holland Township.—Hager, Duckworth, Bloom.

Alexandria Township.—Martin.

Bethlehem Township.—Turkey Hill, Swayze, Alpaugh, Wild Cat, Church or Van Syckle, Rodenbaugh, Asbury, Miller.

Lebanon Township.—Banghart, Terraberry, Fritts, White Hall, East Castner, Hunt or Pidcock.

Morris County, Washington Township.—Sharp, Hann, Hunt, Stoutenburgh, Fisher, Marsh, Dickinson, Hunt, Lake, Naughtright, Sharp, Rarick, Hopler.

Mount Olive Township.—Shouse, Cramer, Smith, Lawrance, Mount Olive or Solomon, Drake, Osborn.

Roxbury Township.—Hilts, Baptist Church, King, Gove.

Jefferson Township.—Davenport, Nolands, Hurdtown Apatite, Hurd, Lower Weldon, Weldon, Dodge, Ford, Scofield, Fraser, Duffee, Shongum.

Warren County, Franklin Township.—Cline, Smith, Dean.

Washington Township.—Chapin and Lommasson, Lanning, Oxford Furnace.

Mansfield Township.—Creager, Mitchell, Johnson, Bald Pate, Egbert Church, Rockport, Shafer.

Independence Township.—Searle, Bucks Hill.

Allamuchy Township.—Frace, Young, Pyle, Axford, Bryant, Excelsior, Eureka, Haggerty, Brookfield or Waterloo.

Sussex County, Byram Township.—French, Smith or Cascade, Allis, Hude or Stanhope, Wright, Silver, Haggerty, Lawrence, Gafney.

Sparta Township.—Sickles, Goble, Boss, Sherman, Bunker, Ogden.

Hardyston Township.—Greer Farm and Franklin Iron Company, Hopewell Forge.

Vernon Township.—Canistear, Tracey and Crane, Henderson, Williams, Rutherford Estate, Hunt, Wawayanda, Green, Welling.

Passaic County, West Milford Township.—Kimble, Budd and Hunt, Scranton and Rutherford, Jennings and Rutherford, Clinton Tract, Wallace, Squiers.

Hager Mine.—The Hager Mine has not been described or mentioned in any of the Reports of the Survey. It is on lands of John Hager, 1¼ miles west of Spring Mills, and on the southern foot of the Musconetcong Mountain. About 700 tons of ore were mined here by Hartpence, Van Syckel & Bird several years ago. Two shafts were sunk to a depth of 40 feet. The ore found near the surface was weathered and was of a rusty red color. It had lost the sulphur originally in it in the form of pyrite. The ore from the bottom of the shafts and workings shows the pyrite quite regularly disseminated through the

mass. The Holland Mining Company has recently re-opened this mine. John Jameson, superintendent, in a letter dated December 11th, says that in the lower shaft, at a depth of 60 feet, the vein is 7 feet wide and pitches (dips) to the southeast. And there is much less sulphur than there was at a depth of 50 feet. The company is now shipping 20 tons of ore a day. By the first of the year they expect to have both shafts in working order, and to raise 50 tons a day. The following analysis of a sample received from Mr. Jameson, indicates the richness and quality of the ore:

ANALYSIS.

Metallic iron	56.13 per cent.
Sulphur	7.59 "
Phosphorus	0.29 "
Titanium	0.84 "
Manganese	none.

The percentage of sulphur is unusually large. The titanium in the form of titanic anhydride amounts to 1.40 yer cent.

Duckworth Farm.—This locality is one-half mile west of Little York, and near the foot of the Musconetcong Mountain. A hole was dug here about a hundred years ago. A few years since Mr. Duckworth sunk two shafts, one 50 feet deep, the other 25 feet. A thin bed of ore was found between the gneissic strata. A sample of the ore was analyzed, and found to contain 64.32 per cent. of metallic iron, .0039 of phosphorus, and 9.92 of insoluble matter. The work of exploring was resumed last autumn. Thus far these searches are reported as not very successful.

Bloom Farm.—In the Report for 1874 the Bloom openings were noticed under the head of "Little York Mine." In the Report for 1875 an analysis of a sample of ore from P. C. Bloom was published. The ore was lean, and contained 4.7 per cent. of titanic acid, and *traces* only of phosphorus. Nothing has been done here since that Report was published. The locality is on the southern foot of the Musconetcong Mountain, one mile west of Little York.

Martin Farm.—Magnetic iron ore is reported to have been found in mining quantity on the farm of Wm. C. Martin, east of Little York, and on the southern slope of the Musconetcong Mountain.

Turkey Hill, or West End Mines.—A short account of these mines was published in the Report for 1874. During a very short visit to

them last autumn, the following notes were obtained from the superintendent, N. H. Heft: The mines were discovered and opened by Mr. Heft in September, 1872. They have been worked without interruption to the present time, and they are now worked by G. M. Miller & Co. and Daniel Runkel. Two veins are known, 60 feet apart, but one only is worked to any extent. There are seven openings on it, and two trial pits further east are now being sunk. The course, or strike, is N. 75° East, and the dip is about 60° towards the south-southeast. The walls are clean and straight, and generally parallel. The rock of the foot-wall of the big vein is generally a dark-colored gneiss; that of the hanging-wall is a coarse crystalline gneiss. The size of the vein varies somewhat on account of *rolls* in the foot-wall. But they do not, in any case, cut out the vein. The vein runs from 6 to 20 feet wide. At one place it was 40 feet wide, but in it was a horse of rock, 8 feet across. Beginning at the west the several shafts are located as follows: A slope 75 feet deep, connected with shaft No. 1, which is 100 feet from it; from No. 1 to No. 2, 630 feet; from No. 2 to No. 3, 380 feet; from No. 3 to No. 4, 340 feet. The latter two are connected by underground workings. The others are separate. East of No. 4, 600 feet, they are now sinking on the vein, and also 3000 feet from the same shaft. Of the several shafts, No. 4 is 75 feet deep vertical, then on the foot-wall, inclined, over 100 feet deeper. It is the deepest on the property. The company has five Copeland & Bacon hoisting engines. The boiler-house is near No. 2 shaft, and has four plain cylindrical boilers. Culm is used for heating. They are now raising 1500 tons of ore a month, all of which is sold to the Bethlehem Iron Company, and is used for Bessemer steel. Between shafts 1 and 2, 174 feet in length of the vein is worked by Daniel Runkel, of Asbury.

Since the completion of the Lehigh Valley railroad the ore from these mines has been shipped from West End station. The company is now constructing a branch railroad from West End to the mines. The grade is such that cars can be run by gravity to the station. The company is preparing to work the mines to a much greater extent than heretofore, and under the energetic superintendence of Mr. Heft the outlook of their mines is promising.

The Crane Iron Company is opening on the line of the Turkey Hill Mine, northeast of the latter and near Bethlehem.

Swayze Mine.—This mine also is owned by G. M. Miller & Co. It was called the Bethlehem Mine in the Survey Report for 1873. Work here was stopped in 1875, after reaching a maximum depth of about 90 feet. The present owners are re-opening it and getting ready to work it again. According to Mr. Heft, there is a line of attraction from this mine, traceable southwest, to the Turkey Hill Mines.

Alpaugh Farm.—A shaft 25 feet deep was sunk on the Alpaugh estate, 1¼ miles from West End and southeast of the Swayze Mine, and a small vein opened, but the volume of water was so great that further exploration without an engine for pumping was impossible, and the work was stopped.

Wild Cat Mine.—The Wild Cat Mine is near Bethlehem. It is worked by Theodore Hoffman, of Clinton, who reports a layer of ore about four feet thick; then rock, two to three feet thick; then ore again—the lower stratum taking a turn gradually downward. The depth of the opening is about 30 feet. The ore is shipped to the Keystone furnace, Pennsylvania.

Church, or Van Syckle's Mine.—This old mine is on lands of John T. Leigh. It was worked last in 1875, by Cooper, Hewitt & Co., and the ore was smelted at Durham. The ore is remarkable on account of the large percentage of titanium in it and the traces only of phosphorus. The mine is two miles from the Easton and Amboy railroad.

Rodenbaugh Mine.—This locality has been opened since the last report on the iron mines of the State appeared. The lease is held by Theodore Hoffman, of Clinton. The openings are three or four trial shafts, none of which are more than 25 feet deep. They are on the crest of the Musconetcong Mountain, about 300 feet above the Asbury depot and the Central railroad. At the most westerly shaft the strata dip steeply towards the northwest; in others the dip is towards the southeast. The hornblende in the rocks and mixed in the ore is noticeable. Very little ore has been sent away.

Asbury Mine.—This mine is on lands belonging to Daniel Osmun. It has been leased lately to R. A. Laity and Edward Moyle. The mine was worked many years ago. A tunnel, 100 feet long, runs in the side-hill across the strata to the vein, and from that the workings go down 130 feet below the tunnel level. Near the mouth of the adit, or tunnel, there is a coarse crystalline granite. The vein in the

bottom of the mine is said to be 6 feet wide. The vein is opened to the south, higher on the hill, in several open cuts. The ore and the rock associated with it, both contain hornblende. The strata dip about 60° to the southeast. The ore is lean. When visited, Messrs. Moyle and Laity were preparing the mine for work, so that it was not in a favorable condition for inspection. It is so conveniently located for working and so near to the railroad that it can be worked profitably, if there be a vein of good size and carrying a fairly good ore.

Miller Farm.—Messrs. Laity and Moyle have leased this property also, and have begun exploring it further. They report two small veins. The locality is one mile southwest of Glen Gardner.

Banghart Mine.—This mine is now held by Theodore Hoffman, who reports the shaft as 35 feet deep and on a vein of good ore, which is 3 feet wide. As this place is one mile only (northeast) from Glen Gardner station on the Central railroad, it is convenient for transportation.

Terraberry Farm.—As the last report on iron ores did not mention this locality, it is here given, although it is now idle. It is less than a mile south of White Hall, Hunterdon county. The openings are little more than test pits. The ore is lean and mixed with mica and hornblende.

Fritts Farm—Alvey Gray's Farm.—The Saucon Iron Co. is lately reported to have leased this property and begun work on it. It is a half a mile southeast of White Hall. The ore on the bank at the time of a visit in 1875, was lean. Up to that time only about 400 tons of ore had been taken out of the shaft.

White Hall, East.—The locality thus named remains idle.

Castner Farm.—Some ore has been mined on the farm of Adam Castner, on the brow of the mountain and three miles northwest of White Hall.

Hunt, or Pidcock Mine.—This mine is not worked. At a recent visit some ore was seen on the bank. It is lean. There is a positive attraction of 10° to 20° about the main opening, which is 100 feet long from east to west, and east of the old mine holes. A horse whim was used for hoisting the ore. The opening was free from water 35 feet down. The mine is nearest to the canal at Port Murray, but the road is very hilly.

Sharp's Mine, Pleasant Grove.—Work stopped at this locality in

1874. About 50 tons of rich ore were taken out from a narrow vein. The shaft had reached a depth of 60 feet.

Hann Farm.—On the farm of Wm. Hann, northeast of Pleasant Grove, mining has been done at intervals by two distinct parties. Very recently the property has been leased by Wm. W. Marsh, and the ore has been uncovered in two shafts. At the southwestern openings, made by Marsh & Trufant, the vein was thin and dipped gently towards the south. Towards the northeast, A. H. Seam & Co. worked up to 1875, and W. W. Marsh, of Schooley's Mountain, after that time. The amount of ore taken from this opening was estimated to exceed 5000 tons. The strike of the vein is a few degrees south of west, and the dip is about 30° towards south-southeast. A succession of open pits were dug in working the two parallel veins. The ore of the foot-wall vein is brownish; that of the other vein is bluish. Grains of feldspar give the mass a speckled appearance.

An analysis of an average sample was made since the mine has been re-opened. It shows the following percentages: of

Metallic iron	56.970	per cent.
Sulphur	0.068	"
Phosphorus	0.367	"
Manganese	none.	
Titanic acid	1.050	"

Hunt Farm.—Ore was found in digging a well and a cellar on the farm of H. Hunt, one mile southwest of Schooley's Mountain and near the Pleasant Grove road. An exploration is about to be made to test the locality.

Stoutenburgh Mine.—The Stoutenburgh Mine was idle from 1873 to 1877. The total product in the first working period was 6000 tons, and a depth of 115 feet was reached. The vein at the bottom was *cut out* to a width of 2 feet when the lease was given up. In 1877 Mr. Stoutenburgh began prospecting for other veins, and up to the present time he has sunk nine trial pits, and has found ore in each one of them. What may now be termed the *mine* is several rods southwest of the old shafts. In the main shaft the ore was struck 7 feet beneath the surface of the ground. This shaft has a vertical depth of 22 feet, and then descends on the foot-wall, towards the southwest, 70 feet—in all over 90 feet. From the shaft the ore has been worked out each way by drifts, one of which connects with a second shaft, 35 feet distant. The westerly drifts have opened a lean ore, consisting of magnetite in

a granitic rock, and it has varied from 1 to 3 feet in width. Towards the east there is more regularity in the structure, and the vein attains a maximum thickness of 7 feet. The dip is towards the southeast, but is steeper as it gets down. The foot-wall is fairly defined, but there are traces only of a hanging-wall. The rocks are much disintegrated. In the eastern shaft, which is 35 feet deep, the rocks are harder and the vein is 6 feet wide.

There is considerable water in the mine, and a small engine is in use for pumping and for hoisting the ore. On account of the disintegrated nature of the ground, the ore can be picked out. Some of the finer ore has to be washed to remove the earth. There is some feldspar mixed with the magnetite. It is carted to the High Bridge railroad at German Valley, and shipped to Allentown, Pa.

Mr. Stoutenburgh found a vein 5 feet wide of lean ore, at a depth of 22 feet, in a shaft a few rods east of the old mine. On account of a scarcity of hands, the further sinking in this shaft has been deferred for the present, until it may be needed. On the west of the old mine, and on the west side of a lane, there is a shaft 35 feet deep, in which, at the bottom, the vein is 3 to 4 feet wide and bounded by good walls. The ore is rich. Drifts each way about 30 feet long have opened a length of 70 feet on this vein.

In the fields east of the mines there are two main belts of negative attraction, which extend northeastward to the public road. The attraction varies from 5° to 35°. Much *float-ore* has been picked off these fields. It is possible that they indicate the easterly extension of the vein of the old mine. Their development is awaited with interest.

Fisher Mine.—This mine has been known as the Beattystown Mine. It was first worked by the owner, J. B. Fisher; afterwards by Wm. W. Marsh, of Schooley's Mountain, until the depression in the iron ore trade caused the suspension of operations, since which time it has been idle. Several thousands of tons of red ore were taken out of a large open cut, and shafts sunk at each end of the opening, one of which was 140 feet deep, and penetrated a rich ore, but containing some sulphur. A large body of ore is still in the mine, and *in sight.* From the mine to the railroad depot at Hackettstown the distance is four miles.

Marsh's Mine.—The mine on the farm of Wm. W. Marsh, near the Schooleys Mountain House, was opened in 1855 and worked for a short time, and yielded from 3000 to 4000 tons of ore. Again in

1872–3 it was in operation. The first mining was open cuts in the surface ore. In the shaft sunk in 1872–3 a vein 3 to 4 feet wide was found, dipping to the southeast. The ore was rather lean, and contained quartz. Some observations with the dipping needle, made at a recent visit, show both positive and negative attraction about the mine and a belt of attraction towards the northwest; and these run west-southwest. Several tons of surface ore have been picked up from the adjoining field. The indications are very good, and the mine is soon to be put in working order. An average sample of the ore was lately received from the owner, Mr. Marsh. It has been examined, and contains of

Metallic iron	57.620	per cent.
Sulphur	0.055	"
Phosphorus	0.167	"
Manganese	none.	
Titanic acid	2.050	"

Dickinson's Mine.—This mine has been idle for more than ten years.

Hunt Farm.—One mile northeast of Schooley's Mountain Post-office and of Marsh's mine, several pits were dug by Mr. Bess on one of the farms of Hon. H. Hunt, and ore, much like that of Marsh's mine, was found. About 300 tons were mined. The place is reported to have been leased very recently.

Lake Farm.—This locality is east of Schooley's Mountain Post-office and in Washington township. A shaft thirty feet deep was sunk by the lessees, Cook & McAuley, in 1875, and a little ore was taken out. Some of it was very rich and strongly magnetic, but much of it was lean—a mixture of coarse crystalline rock and ore. Lately mining here has been begun, and it is said that some good ore has been found.

Naughright Mine.—The first notice of the Naughright Mine by the Survey was in the Report for 1873. The last annual report contained analyses of two samples of the ore of the mine, sent to the laboratory by Theo. Naughright. The mine has been idle since February last. It has been leased recently by D. Runkle & Co., and it is to be worked for the Keystone Furnace, near Glendon, Pa.

Sharp Farm.

Rarick Farm.

These localities are not now worked.

Hopler Farm.—The work of re-opening the vein on this property has been resumed, and it is reported that ore of a good quality has been found.

Cramer Mine.—Some ore from the Cramer farm was sent to the laboratory in 1877, and the analyses were published in the Report of that year. The place has not otherwise been noticed in any of the Survey Reports. It is on the western brow of Schooley's Mountain, and about two miles east of Hackettstown. Many years ago ore was got here for the supply of a forge near Hackettstown. The old holes are still to be seen. About twenty-five years ago the place was worked a while by Messrs. Scranton, of Oxford Furnace. In 1873–4–5 the place was worked by a Pottsville company. They had three main shafts on a northeast and southwest line. One of these was 80 feet deep, and another 50 feet deep. Some of the ore was very rich, but in the greater part of that mined there was considerable rock. The vein near the surface dipped steeply towards the northwest, then, as the mine got deeper, it became vertical, and at the bottom had the common, southeast dip. The attraction on the line of shafts and trial pits, going northeast, is regular, although not very strong.

Warne & Shouse Tunnel.—This locality is referred to as a good illustration of costly exploration, rather than as a mine. It is 1¼ miles east of Hackettstown and about 50 yards south of the Budd's Lake road. It was driven over 300 feet into the hill-side, and was designed to strike a vein of ore which is indicated by a long line of positive attraction on the hill, north of the road. Two shallow test pits on this line did not discover a workable thickness of ore. A small fractional part of this adit would have sufficed to test the surface.

Smith's Mine.—This mine was described in the "Geology of New Jersey." It has not been in operation since that Report was issued. The mine yielded a large amount of ore, but it contained pyrite. It is now owned by Aaron B. Mitchell.

Lowrance Mine.—The openings known as the Lowrance Mine were made many years ago. No work has been done there since the first openings. The ore is sulphureous. There is a good belt of attraction. And the mine is so near to both canal and railroad that it has advantages for shipment of its ores.

Mount Olive Mines.—The Mount Olive Mines have been worked very little since 1857. There is a long line of ore opened on the lands of A. L. Solomon, John Drake, and others, between Mount Olive and Turkey Brook. Some work was done here in the winter of 1874–5, by Wiley, McCormack & Wistar and by Uhler & Solomon. The

slope on A. L. Solomon's property was 100 feet deep. The dip of the vein was 35° at the surface, but increasing to 45° towards the bottom. The shoots of ore pitched towards the northeast. The average thicknesss of the ore was ten feet. Uhler & Solomon's slope on Drake's land was 60 feet deep. Three veins were found, close together; only the middle one was worked. The surface ore was of a rusty red color. That from the bottom of the slope and the lower drifts contained considerable pyrite. The most southwesterly opening on this lease opened a shot-like ore, but pyritiferous, as is all the ore of this line.

These openings were visited in October last. The work of pumping out the water and retimbering the shaft, preparatory to mining, had just been begun by Wm. E. George & Co., the present lessees. They proposed to drain the openings on the Drake place by connecting them with an unfinished adit which runs in at the foot of the hill. The mines are about two miles from the High Bridge railroad at Flanders, and less than four miles from Stanhope. Under one management the working of the several openings can be so systematized as to be done economically. Their present outlook appears to be more promising than it has ever been.

Drake's Mine.

Osborn Mine.

Hill's Mine.

Baptist Church Mine.

Not in operation.

King Mine.—This Mine has been recently opened on the hill west of Drakeville. Some exploration was made near the present openings several years ago by James Lewis, of Dover. It is reported to have been leased by the Thomas Iron Co.

Gove Mine.—The Gove mine is a new mine which has been opened since the report of 1873. It is in Roxbury township, Morris county, and one mile northwest of Drakesville station. It is worked by Francis M. Gove, of Dover. Very recently it is reported as sold to James Sutherland, of New York city. This mine is less than a mile from canal and railroad at Shippenport.

Davenport Mine.—The Davenport Mine has not been worked since it was described in the "Geology of New Jersey."

Noland's Mine.—The mine at Noland's Point, also, has not been in operation for several years.

Hurdtown Apatite Mine.—The occurrence of magnetite with the

apatite at this place, and the geological formation, justify placing it in the list of mines. It has not been worked either for the apatite or as an ore of iron.

Hurd Mine.—The Glendon Iron Company continues to work this mine, and it is maintaining its reputation for regularity and for the richness of its ore. The shoot is 60 feet high and 40 feet wide, and the slope has reached a length of 1450 feet. The only recent change is in the clean walls. Formerly there were no well-marked planes of division between the ore body and the bounding walls. The large annual yield of this mine is working the shoot down rapidly, and lengthening the slope about 100 feet a year. It is a matter of practical as well as geological interest to know the maximum length of such workable shoots of ore. Judging from the known length of some of them, where they are worked on the *side*, and not on the *end*, as is here the case, it is safe to conclude that it may continue quite as far as it can be conveniently followed in the present mode of working. Machine drills and air compressors have been lately introduced, and the capacity of the mine has been enlarged. The ore is shipped by way of the Ogden Mine railroad and Lake Hopatcong, and thence by canal or rail to the Glendon company's furnaces at Glendon, Pa.

Lower Weldon Mine.—This mine has been idle for several years.

Weldon Mine..—The Weldon Mining Company, Wm. Allen Smith, manager, is preparing to work this mine. It stopped about six years ago. It has always been an interesting mine geologically, on account of the two approximately parallel shoots of ore which pitch towards the northeast, and approach one another as they descend. It is hoped that further working will discover ore in quantity, and also answer questions as to structure.

Dodge Mine.—This mine is also to be re-opened very soon by the Weldon Mining Company.

Ford Mine.—The Ford Mine is worked by A. Pardee & Co., for the supply of their furnaces at Stanhope. It is a little over 200 feet deep. The vein which is worked continues large, and is opened a distance of several hundred feet in length. The walls dip very steeply towards the southeast. The Ogden Mine railroad is the outlet for the ore to Lake Hopatcong.

Scofield Mine.—The Crane Iron Company worked this mine until September, 1874, when mining was suspended. The vein here is the

northeastern extension of the east vein of the Ford Mine. It joins the latter on the southwest. It is owned by the Crane Iron Company.

Fraser Mine.—This mine has been idle for several years.

Duffee Mine.—This mine has been idle for several years.

Shongum Mine.—This mine has been idle for several years.

Cline Mine.—As there has not been any reference to the Cline Mine in previous reports of the Survey, a short notice is here inserted. It is on the foot of the Pohatcong Mountain, 1¼ miles southeast of Stewartsville, in Warren county. The openings consist of a shaft 20 feet deep and an adit 200 feet long driven in on the vein, and are about 100 yards east of Mr. Cline's residence. A considerable amount of ore was taken out and sold. That which was seen on the dump, when it was recently visited, was rather lean. The attraction about the openings is light and positive.

Smith's Openings.—Two shafts and a shallow pit were sunk on lands of Robert J. Smith, of Bloomsbury, a few rods east of the Cline Mine, and on the side of the mountain. The shafts are 20 feet deep. The work was done under a lease by Keler, Reese & Co., who mined 200 to 300 tons of ore, and sent it to Hellertown, Pa. The ore is lean, containing some altered feldspar and some hornblende. Pyrite occurs in some lumps. The walls are of hornblendic gneiss. There is a line of positive attraction (10° to 20°) connecting the shafts.

Dean Lot.—The Dean lot adjoins Smith's land on the east. There are here two lines of openings, the westernmost of which is 150 yards east of that of Smith. Keler, Reese & Co. worked this place also. None of the shafts exceed 25 feet in depth. The ore is lean. At the northeast shaft, on the western line, the ore is magnetite, mixed with epidote. That of the southern shaft has a schistose structure, in which the ore is in parallel planes, or *strings*, alternating with rock. It contains pyrite also. The eastern vein is not more than 100 yards from the other, and on it there are two shafts. The ore here is also lean. There is a third shaft on another vein, and 50 yards south of the last-mentioned line.

These openings on this part of the Pohatcong Mountain were made previous to the panic, and no work has been done since. All the ore obtained was more or less mixed with rock. The lines of attraction are quite regular, but its amount is slight. The location is within easy distance of railroads at Bloomsbury and Stewartville, and of the canal at the latter place.

Chapin & Lommasson Diggings.—There does not yet appear to be a workable vein of ore here.

Lanning Farm.—The explorations on this place were stopped several years ago.

Oxford Furnace Mines.—The mines at Oxford furnace are locally known as the *New, Car-Wheel, Welsh, Staley, Washington* and *Harrison Vein*, and the *Franklin Vein*. The last named is west of the furnaces, and is not much worked. The shoots in the New Mine, which were extraordinarily large, and carried a very rich ore, have become smaller and the mine has not been worked so vigorously as in former years. The developments of the Washington and Harrison veins are now very promising. These veins are close to each other, and are worked together. The line of magnetic attraction over these veins has been mapped out by Wm. H. Scranton, and a copy of the survey has been placed by him at our disposal. It is inserted under the head, "Searching for Magnetic Iron Ores." This line is one remarkable for its length and constancy, and it indicates a large supply of ore for the works here. The northeastern end of this line was opened in 1860. Work was resumed here last October. Towards the southwest the sinking of two shafts was begun in November. The results of these openings will be awaited with interest, as tending to prove the value of magnetic surveys. It is hoped that they will be suggestive to land-owners, and those persons who are developing iron ore property. They show much more than can be seen from a careless and hap-hazard examination with the dip compass.

The Welch mine is on the hill near the Car-Wheel shaft, and 150 yards northwest of it. The vein is parallel with the slope vein, and nearly at right angles to the Car-Wheel. It appears probable, according to Mr. Scranton's explanation, that it and the New and Car-Wheel Mines are on one vein, which is here bent around so as to run a short distance in a northwest and southeast direction.

The following determinations of phosphorus made on samples, carefully averaged by Wm. H. Scranton, show the character of the Oxford ores:

Staley Mine ore	0.160	per cent.
Car-Wheel "	0.050	"
New Mine "	0.108	"
Welch "	0.050	"

Creager Mine.—This place has not been worked in four or five years.

Mitchell Mine.—No work at mining has been done here for several years past. Many thousands of dollars were spent in the original explorations.

Johnson's Explorations.—The openings at this locality discovered a narrow vein, but no work at mining has been done.

Bald Pate Mine.—The Bald Pate Mine has been worked for short periods by different parties. The last was a Boston firm, who stopped in the autumn of 1876. Altogether, the mine has produced about 2000 tons of ore. The mine is interesting geologically, on account of the large body of white quartz rock which was struck in the first shaft, which was sunk by Mr. Henry, of Oxford. It was found at a depth of 40 feet, and continued to the bottom, 96 feet deep, and also in a drift northward. The middle shaft, sunk in 1873 by the late Philip Smith, was in gneiss and ore. The shaft of the Boston firm is northwest of the Henry shaft, and is 60 feet deep. In it a greenish, slaty rock was found on the hanging-wall side of the ore. All the workings at this place show the existence of irregular strings and masses of ore, rather than any well-marked ore-bed. The ore is coarse crystalline, and is rich. The mine is on the farm of Amos Beatty, and it is reported to have been lately leased and re-opened.

Rockport.—The searches near Rockport were given up, as no ore in quantity was discovered.

Shafer Mine.—This locality is reported as being near the Bald Pate Mine. It has not been visited. A sample of ore sent to the laboratory by Charles Scranton was analyzed. The following percentages were determined:

Insoluble in acid	26.40
Peroxide of iron	64.60
Titanic acid	4.95
Phosphoric acid	0.20
Sulphur	...
Manganese	traces.

Or—

Metallic iron	45.22
Phosphorus	0.09
Sulphur	0.028

Egbert Church, or Smith Mine.—This mine was worked up to autumn of 1876, and yielded several thousand tons of ore. When

visited in the autumn of 1875, it had reached a depth of 130 feet, and the lengths of the workings were 65 feet towards the southwest and 150 feet northeastward. The foot-wall was gneiss, and the ore came off clear from it, but in the hanging-wall side there was some rock mixed with ore. The strike of the vein was south 15° west, and the dip east-southeast. South of the southwestern shaft there is a positive attraction of 10° to 30°. The same degree of attraction is noticeable about the north shaft.

Pyrite is found in all the ore of the mine, and it necessitates roasting. A considerable part of the ore was worked up at Pottsville, Pa.

On the Egbert property, one-fourth mile southwest of the mine, there is a long line of attraction in the fields west of the road, and five openings from 20 to 40 feet deep on this line were made by the late Jacob Stiers, but without finding any workable vein of ore. The attraction is positive, and varies from 10° to 40°.

Searle Mine.

Buck's Hill.

Frace Farm.

Young's Farm.

Pyle Farm.

Axford Farm.

Bryant Mine.

Excelsior Mine.

Eureka Mine.

These mines have not been in operation for several years.

Haggerty Farm.—The Haggerty farm openings were described in the Report for 1876. They were made in 1874, and about 100 tons of ore were taken out of them. The attraction is traceable over a long and rather broad belt, which runs from west-southwest to east-northeast. The openings are not deep enough to afford any safe conclusions as to the probable size of the vein. The place is so near to canal and railroad that it has advantages in the way of transportation. A recent analysis shows that the ore contains of

Metallic iron	58.55	per cent.
Phosphorus	0.33	"
Sulphur	0.05	"
Titanic acid	4.20	"

Brookfield, or Waterloo Mine.—The Waterloo Mine has been idle

since December 31st, 1873. It was the most productive of the openings north of Hackettstown, and yielded a good ore.

French's Place..—The openings on this property have not been continued, and have not developed into mining operations.

Smith, or Cascade Mine.—The Cascade Mine was described in the Report for 1873. It was in operation from 1869 to 1877. It belongs to the Peter Smith estate, and is near the Sussex railroad and one and a half miles northeast of Waterloo.

Allis' Openings.—The work of opening the line of ore on the Allis property, northeast of the Smith tract, has been discontinued.

Hude, or Stanhope Mine.—The Hude Mine tract is owned by the Dickerson estate, and is now worked by John M. Barnes, of Ironia. There are fifty distinct openings on the property, and all on the western end of the ridge known as Mine Hill. The deepest of these does not exceed 50 feet in depth. The openings have been made so as to get out the surface ore most economically. There seem to be a number of shoots of ore, which pitch easterly at a small angle. Short anticlinal and synclinal folds of ore have been worked out in several of the openings. Thus, in openings Nos. 11 and 26, the dips are towards an axis between them. Nos. 13 and 9 show a synclinal. In No. 1 there is more regularity, and the vein dips towards the southeast. But in the absence of any survey it is almost impossible to understand the relations of the several exposures of ore to one another. The vein worked at the time the mine was visited dipped 30° towards the east, and was 12 feet thick, but the walls are not well defined. In a part of this vein the ore was very rich and pure, whereas another portion carried pyrite. The ore from this opening is black, and has a lustrous fracture. The pyritous ore is harder. In several of the openings the first ore taken out was found to have lost the sulphur by oxidation of the pyrite. This variation in the nature of the ore has made it necessary to sell it in separate lots, according to quality. The best ores have been used at Bethlehem, Pa., for Bessemer steel; those carrying more phosphorus have been carted to the Stanhope furnaces. In mining, the walls have generally been found firm, and consequently little timber has been needed. The only water is that from the surface, which the rains pour in—in some cases enough to interfere temporarily with the working; but generally the mining has been done

with economy, and thousands of tons of ore have been obtained from these shallow openings. Mr. Barnes started a tunnel from the foot of the hill on the south and near the property line, but it was stopped when in about 100 feet. It cut the vein of opening No. 1 only. The extension of this tunnel into the hill might discover other veins, and very probably would do so, as it seems hardly possible that so many outcrops are one connected ore body.

This mine is interesting to mineralogists as the locality of molybdenite and molybdic ochre. It occurs in the ore, scattered through the mass, and, more rarely, in the rock. Good specimens are not common. They are found at Nos. 6, 24 and 1.

The mine has been worked at intervals. The present operations were begun the 1st of October. As it is only a mile to the canal and railroad and to the Stanhope furnaces, the location is very convenient. The further exploration and opening of the ore at this place are both promising, and, geologically, very interesting.

On the same hill, and on both the northwest and the southeast slopes, Cooper, Hewitt & Co., have lately sunk several trial pits in search of ore, but without finding any of workable extent. There is a light, positive attraction on their leasehold close to the Hude lot. And the southeast dip of the veins ought to bring some of them on to their property.

Wright Mine, or Budd Mine.—This locality is named from the land-owner, Wm. Wright. It is a quarter of a mile east of the Hude Mine, and two miles from the Stanhope depot. It is on the north slope of a rocky hill. There are four openings. That to the southwest is from 15 to 20 feet deep, and is an old trial pit. About 500 feet towards the northeast is the main working shaft. This shaft is not less than 60 feet deep, descending on the foot-wall of the vein. A drift 40 feet long connects it with the western (ladder) shaft. The northeast heading is about the same distance from the shaft, making a length of 80 feet opened on the vein. The dip averages 50° towards the southeast. In the sink the breadth of the ore body is 9 feet. But in it there is some rock. The ore is blue, hard, and contains pyrite. That from the top of the vein had a brownish red color, due to the oxidation of the pyrite.

There is another trial pit 50 feet northeast of the whim shaft, and which is 25 feet deep. On the strike of the vein between the shafts,

and prolonged 200 yards towards the northeast, there is a belt of attraction, which is negative, and which varies in intensity from 10° to 50°.

The present lessees of this property are Smith & Rusling, of New York city, and S. B. Sahler is superintendent.

Silver Mine.—This old mine continues idle.

Haggerty Mine.—This mine also continues idle.

Lawrence Farm.—The long line of attraction on this property has not been tested, except in the old mine holes which were dug many years ago.

Gaffney Mine.—This mine is on the farm of the Rutherfurd estate, adjoining the Lawrence on the northeast, and near the Sparta line. A small map of the attraction on the line of the old holes was printed in the Report for 1873. In the following year the place was opened, and subsequently it was taken by the Harrisburg Steel Company, and worked by them in 1876. It had reached a depth of 90 feet, and the vein of ore was 6 to 8 feet wide. The ore was of good quality. It was carted to Andover, six miles distant. The existence of a workable vein of ore at this place confirms the indications as they were represented in the little sketch map made in 1873. The distance to railroad is a serious drawback in working the mine. It is now idle, but is about to be opened again, by McCormick & Co., of Harrisburg.

Sickles Mine.—This mine was worked for a short time in 1870 and 1871 by the Bethlehem Iron Company. The mine, as opened at that time, was described in the Report for 1873. Subsequently it was worked by Gen. Stahl and a New York company. Last November a lease of the mine was taken by the Blooming Ridge Iron Company, and it is now worked by them, under the superintendence of A. H. Harris.

Goble Mine.

Boss Mine.

These mines are still idle.

Sherman Farm.—This locality is one mile east of Sparta and a quarter of a mile north of the Dover turnpike, and on the west of the road to the Ogden Mine. It was visited in 1875, but there has been no work done since that time. About 100 tons of ore had been taken out of a large open cut, 50 feet long and 35 feet deep. There is no regular vein and no plainly stratified rocks, but a large body of lean ore.

Bunker Farm.—The opening on this farm is about 50 yards south of the Sherman opening. And the open cut is with that the same size. The dip of the strata is 30° towards the south. Next to the foot-wall there is a breadth of 5 to 7 feet of ore, mixed with rock; then gneiss for 5 feet; then ore 5 feet. The locality is within carting distance of the Ogden Mine railroad.

Ogden Mines.—Two companies are here at work, viz., the Musconetcong Iron Works and the Allentown Rolling Mill Company. The southwestern mine of the group, known as the *Davenport Mine,* is owned by the Sussex Iron Company. It is not in operation. The *Roberts Mine* is worked by the Allentown Rolling Mill Company. Adjoining it on the northeast is the *Pardee Mine,* worked by the Musconetcong Iron Works. Both the Roberts and the Pardee Mines belong to the Ogden Iron Company. The Ogden Mine railroad and the Morris canal afford direct means of transportation to the furnaces at Stanhope and to the Lehigh region.

Greer Farm and Franklin Iron Company's Tract.—The line of attraction on these tracts, in Hardyston township, has not been further explored.

Hopewell Forge Tract.—There have been no further developments on this tract.

Cannistear Mine.—This mine has heen in operation during a part of the year and several thousand tons of ore have been mined and stacked at the mine. The vein is large but the ore is rather lean. The mine is owned and worked by the Franklin Iron Company.

Tracey and Crane Farms.—These openings have not been worked lately.

Henderson Farm.—These openings have not been worked lately.

Williams Mine.—The Williams Mine was worked last by John Linn and others, in 1876, since which date it has been idle. It had attained a depth of 135 feet. There were three shafts on a line of about 100 yards. The ore was shipped at Snufftown station, five miles from the mine. The completion of the McAfee Valley and Warwick railroad will bring this mine a little nearer to market.

Rutherfurd Estate.—This line has not been further opened since our last Report.

Hunt Farm.—This line has not been further opened since our last Report.

Wawayanda Mine.—The Thomas Iron Company own this mine and the Wawayanda furnace tract. As soon as the new railroad in the Vernon Valley is done, the working of this mine is to be resumed. It has been idle for over two years.

Green Mine.—This mine also is owned by the Thomas Iron Company and is not in operation.

Welling, or Ten Eyck's Mine.—The locality here styled the Welling Mine is a new opening on the lands of John and Thomas Welling, in Vernon township, Sussex county. The place was worked about twenty-five years ago, and the ore was used in the Wawayanda furnace. It was said that it made a very superior iron. A new opening has been recently made by M. F. Ten Eyck, of Warwick, N. Y. An average sample of the ore was sent to the Survey office and was analyzed. The analysis shows :

Metallic iron	54.23 per cent.
Phosphorus	0.033 "
Sulphur	trace.
Titanium	none.
Manganese	none.

The low percentage of phosphorus and the absence of titanium indicate a good ore.

Kimble Farm.

Budd and Hunt Tract.

Scranton and Rutherford Tract.

Jennings and Rutherford Line.

The above-named localities in *West Milford township, Passaic county*, were described in the Report for 1873. The attraction at these places indicated veins of considerable size and length, and the openings discovered workable veins, but they have not been further tested. The distance from railroad transportation has been one of the causes which has retarded their development.

Clinton Furnace Tract Mine Lot.—The openings or mines on the Clinton furnace tract are a mile northwest of the furnace. This vein of ore was opened many years ago. Wm. S. De Camp, of Powerville, re-opened it in 1872–3. In cutting a drift, an old tunnel was discovered. In cleaning out the old shafts ore was uncovered in all of them, and also in several trenches or cuts made across the vein. But in all of them there was some pyrite in the ore. In places there was considerable quartz in it. The dip is 85° towards east-southeast. No

further work has been done since that of Mr. De Camp. From the mine holes to the N. J. Midland railroad at Newfoundland, the distance is three miles, and the road is an easy one.

Wallace Property.—The Wallace Mine is about three miles north of the old Clinton furnace, and in West Milford township, Passaic county. The place was worked in 1874 by Wm. Cisco, and 1500 tons of ore were sent away. The deepest shaft went down 35 feet. The ore was lean. The lease is held by Wm. Cisco.

Squier's Mine.—A full description of the long line of attraction, and the opening made in 1876, appeared in the Report for that year. The mine was worked up to the present year. The ore was used at the Greenwood furnace.

PEQUEST BELT.

Mines in Warren County, Oxford Township.—Schuler, Roseberry, Barton, Shoemaker, Redell, Little, Raub, Pequest, Hoit.

Hope Township.—Smith, Deats, Hendershot, Kishpaugh, Inschow, Stiff.

Independence Township.—Potter, Stinson, Garrison, Davis, Albertson, Shaw, Howell, Carroll, Cummins, Schæffer.

Allamuchy Township.—Maring, Livsey, Haggerty.

Sussex County, Green Township.—Glendon.

Byram Township.—McKean, Byerly, Roseville.

Andover Township.—Andover, Sulphur Hill, Tar Hill, Longcore.

Sparta Township.—Stirling Hill.

Hardyston Township.—Hill, Furnace.

Vernon Township.—Green, Bird.

Schuler Mine.—The Schuler Mine is owned by Samuel Vannatta, of Roxburgh. In 1873 Vannatta & Sherred opened some old holes and took out 50 to 100 tons of ore. The place has not been worked since that time. The ore is manganiferous, and occurs in a grayish-white crystalline limestone. It is said that the mine is about to be opened again.

Roseberry Mine.—This mine has been idle since 1875. It is leased to Peter Fry, who is about commencing work there.

Barton Mine.—When mentioned in 1873, the Barton Mine was not in operation, and the openings were scarcely more than a trial shaft

and pits or trenches. Subsequently the place was leased by Cooper, Hewitt & Co., who worked it until 1876 or 1877, and mined a considerable amount of ore. It has not been going since it was left by them.

Shoemaker Mine.—This place has been idle for some time.

Redell Mine.—This mine has been idle for several years. It has lately been leased to the Bethlehem Iron Company. The ore obtained in 1872, when the mine was in operation, was of superior quality. The veins are very close to the crystalline limestone.

Little Mine.—This place was described at length in the Report of 1873. It has not been worked much since that time. It has been leased recently by the Bethlehem Iron Company.

Raub Farm.—The Report in 1873 gave a full account of the openings made on this place. The Bethlehem Iron Company worked until 1875. One shaft was reported to be 90 feet deep. From this drifts were cut each way—in all nearly 200 feet—on the course of the ore, which is a few degrees south of west. Some fine, earthy, manganiferous ore was mined, and a part of it was used for paint by Wade & Buckley, of Easton. In the shaft southwest of the farm-house, sunk in white limestone, some zinc blende was discovered.

Pequest Mine.—The Pequest Mine was described at length in 1873. It was worked until about four years ago. There seems to have been a large and quite irregular body or shoot of lean ore, which was worked out to the bottom rock on the south and west sides of the opening. The last reports of the working speak of a thin vein at the bottom and under the tunnel. The *Henry tunnel vein*, on the hill-side, north-northwest of the old mine, has not been opened to any greater extent than it was when last described, in 1873. Preparations are making for further mining here.

Hoit Farm Mine.—There has been no mining on this place in four years. Here, as at the Pequest Mine and in the Henry tunnel vein, there appears to be a large body of lean ore. They all have advantages in nearness to railroad and to furnaces.

Smith Mine.

Deats Farm.

Hendershot Farm.

The Smith, Deats, and Hendershot places have not been worked to any extent. They have been idle for four or five years.

Kishpaugh Mine.—The Kishpaugh Mine is one of the most pro-

ductive of those opened of late years. Unknown at the time of the publication of the "Geology of New Jersey," it was first mentioned in the Report for 1873. It has been steadily worked from that time by its owners—the Crane Iron Co. And since that there have been two new slopes put down 100 yards further to the southwest. At the surface of the ground they are 40 feet apart, but, as they diverge, they are 200 feet apart at the bottom. They afford ventilation and safety in case of accident to one. The breadth of ore continues to be large, and it occurs in shoots which pitch to the southwest. The dip is towards the southeast. What is known as a slide of rock separates the old working from the shoots now worked. Scarcely any blasting is needed, as the ore can be picked out. The water is raised by a steam pump (3 inch pipe.) A thousand tons of ore per month are now mined, which is carted seven miles to the D., L. & W. R. R., and thence sent to the furnaces at Catasauqua, Pa.

Inschow Lot.—A specimen of ore from the openings on the Inschow lot was received from Charles Scranton, and was analyzed. The ore is lean, and contains garnet, hornblende, and calcite, with the magnetite. The analysis gave:

Metallic iron	51.40	per cent
Phosphorus	0.017	"
Sulphur	none.	
Manganese	0.79	"

Stiff Farm.—Nothing additional to the account given in 1873 has been reported.

Potter Farm.—The last work in the way of mining on this place was done in September, 1873. The vein is 4 feet wide at the outcrop in one shaft, which is 35 feet deep. It is owned by the Crane Iron Co.

Stinson Mine.—Considerable work in exploring and in opening a mine on this property has been done during the past season by Chas. Scranton, of Oxford. The main shaft was partly filled with water when visited, and consequently the extent of the openings and the size of the vein were not ascertained. The outcropping ledges on the hill near the mine and about the mine holes, consist of impure, crystalline limestones, and epidotic gneiss. They resemble the rocks at the Inschow place, and they occupy the same relative position, lying in and forming the foot hills on the eastern side of the main Jenny Jump mountain range. Some of the ore is black and earthy. Three analyses of ores from this farm have been made for Mr. Scranton:

NUMBER OF SAMPLE.	1	2	3
Metallic Iron	63.12	60.66	49.79
Phosphorus	0.017	0.006	0.02
Sulphur	——	traces.	none.
Manganese	0.65	0.40	2.74

These examinations show some variation in the percentage of iron, a low percentage of phosphorus, and a notable quantity of manganese. The quality of the ore represented by them is very superior; and the presence of calcite and garnet tend to make it work easily in the furnace. A serious drawback to the place is its distance from any railroad lines or from furnaces.

Garrison Farm.—On eastern slope of Jenny Jump Mountain.

Davis Property.—On eastern slope of Jenny Jump Mountain.

Albertson Place.—On eastern slope of Jenny Jump Mountain.

Shaw Mine.—On eastern slope of Jenny Jump Mountain.

Howell Farm Openings.—On eastern slope of Jenny Jump Mountain.

The above-mentioned localities, on the eastern slope of the Jenny Jump Mountain, were mentioned in the Report for 1873. Very little work has been done at any of them since that Report was printed. Good ore in workable quantity has been found at each one, but they are too far from any railroad lines (eight to ten miles) to be worked profitably at present prices.

Carroll Place.

Cummins Farm.

Schaeffer Farm.

Maring Farm.

No work has been done in several years.

The line of attraction on the Maring farm is remarkable for its length and constancy. The lease is held by Thos. Haggerty and the heirs of Richard Stephens, and the development of the locality has been delayed in consequence of business arrangements.

Livesey's Mine, or Hibler Farm.—Since the report of 1873 another vein has been opened on this property, and about 70 rods west of the Hibler house a shaft 70 feet deep was sunk on it. The vein was 7 to 8 feet wide, but it included some rock in thin layers, alternating with the ore. The attraction is traceable from this shaft, in a west-

southwest course on to the Maring property. The shaft at the house failed to strike any vein of workable size or of good ore.

Haggerty's Openings.—The lessee, Thos. Haggerty, of Alamuche, reports the deepest shaft as 40 feet deep, and a good vein of ore. The openings were made four or five years ago.

Glendon Mine.—This place, opened by the Glendon Iron Company, has been idle for at least ten years.

McKean Farm.—This locality was described in the Report for 1874. It has been in operation more or less since it was opened in 1874, and has been worked by Clarkson Bird & Son. The ore is carted about two miles to the Sussex railroad, near the Cranberry reservoir.

Byerly Openings.—These openings are on lands of Robert N. Byerly, one mile west of his residence, and about half a mile southwest of the old Roseville Mine. The openings were made at the beginning of the hard times, and were 5 to 15 feet deep. They are on the western slope of a high ridge of gneissic rock. When visited at the end of last autumn they had so fallen in that the strata could not be seen. There is a line of attraction in a northeasterly and southwesterly direction, and of 10° to 20° negative. In all of the holes a red hematite was found, in small lumps, in the earth. Some of them appear to be quite siliceous.

An analysis of the ore as found in the earth at the holes, gave:

Metallic iron	66.98 per cent.
Phosphorus	0.032 "
Sulphur	trace.
Titanium	none.
Manganese	none.

These figures indicate a very rich and pure ore.

Roseville Mine.—The mine continues idle.

Andover Mine.—This old mine is abandoned.

Sulphur Hill Mine.—The northeast extension of the old Andover Mine is generally known as the Sulphur Hill opening or mine. This place was worked one season by Wm. J. Hance, of Dover. Last April Wm. J. Taylor & Co. began working it. As now opened there are two parallel veins, or ore deposits, although deeper and longer openings may show that the rock lying between them is a horse enclosed by the ore. The strike of the veins is northeast and southwest. The line of strike prolonged to the southwest, passes to the north of

the old mine. The elevation of the outcrop here may account for a part, if not all, of this difference. The main excavation is 65 to 70 feet deep. A tunnel 175 feet long runs in from near the foot of the hill to it and affords a way out for the ore. Cars loaded in the mine run through the tunnel and out on a trestlework dump. At the southwest end of the open cut the bottom rock of the shoot constitutes the end of the opening, and pitching towards the northeast at an angle of about 30°. The hanging-wall is smooth, and dips, at a high angle, towards the southeast. On the other side of the opening the rock is replaced at the bottom by ore. It may be a part of the same body which is opened in the northern or northwest pit. The main opening is now about 100 feet long and about 30 feet wide. The northwest pit, on what is termed the *back vein*, is only 20 feet deep, and not so wide as the other. Towards the northeast a few rods both lines of ore have been uncovered, and on the southeastern a pit 15 feet deep has been excavated in the ore. The rocks associated with the ore in this mine are not of the ordinary types of gneiss, but mixtures of garnet, calcite and some hornblende. In the hanging-wall garnet predominates, and gives the mass a brownish color. In the horse, or rock between the two veins, galena, pyrite and chalcopyrite are common. Some of the lumps of galena are large aggregates of good crystals. These minerals seem to be irregularly distributed through the rock mass, and do not constitute a vein. The ores generally are rather lean. Pyrite appears in seams and bunches in it. Some of the surface ore is weathered reddish in color. L. W. Langdon is superintendent. The greater part of the ore is shipped to Chester, where it is roasted. It will be used in the Taylor furnace at that place. Some ore is sold to furnace companies in Pennsylvania.

Mr. Langdon reports a strong attraction for a distance of 400 to 500 feet northeastward from the openings, and in a belt between two parallel, rocky ledges. The company design repairing the mine railroad, so that the cars can be loaded at once at the dump, and in that way avoid carting to Andover.

Tar Hill Mine.—The Crane Iron Company owns this mine. It has not been in operation since November, 1873.

Longcore's Mine.—This place is not worked.

Stirling Hill Mine of Manganese Iron Company.—This locality was referred to in the Survey Report for 1877, and two analyses were given

of the ores mined there. The property of the Manganese Iron Company is bounded on the north by that of the Passaic Zinc Company, and the openings of the two companies are close together. The mine is reached by a tunnel, 317 feet in length, which runs from the public road, near the eastern foot of the hill, a northwest course, across the strata of white limestone to the ore. The hanging-wall is vertical and strikes south, 82° west. A large body of zinc ore, consisting of silicates of zinc, was found near this wall and at the end of the tunnel. And the mine at this point is 86 feet deep, below the level of the tunnel. West of it, and on the north, occurs the mass of iron ore which is known as franklinite iron ore. Zinc ore lies on the foot-wall on the west of the franklinite. The richer ore resembles massive franklinite. But there is a large proportion of ore which contains some calcite, and other still less rich, wherein the calcite, as a matrix, holds the scattered crystalline masses of ore. The opening, 225 feet long and 160 feet wide, (from the hanging-wall to the Passaic Zinc Company's line,) has uncovered a very large body of ore above the tunnel level. Mr. Martin, the manager, reports the product of the mine for the two years since it was opened, to be 45,000 tons of iron ore, 3000 tons of silicates of zinc, and 1500 tons of franklinite. The ore is said to average 12 to 14 per cent. of manganese and 4 per cent. of zinc. It is a valuable ore for Bessemer metal, and is used largely by the Bethlehem Iron Company, the Cambria Iron Company at Johnstown, Pa.; Atkins Bros., at Pottsville, Pa., and by the Reading Iron Company. On account of the percentage of zinc it cannot be used alone, or in large proportions in a mixture, in an ordinary blast furnace. It is used up to 20 per cent. of the charge without any special contrivance for catching or collecting the zinc. The further working of this mine, in connection with the southwestern working of the Passaic Zinc Company, is looked forward to with interest, as going to prove the existence of one vein, continuous but strangely varying in its mineral composition, from the one mine to the other.

There is said to be a line of attraction towards the southwest, beyond this mine. It may indicate another ore body or shoot.

A branch railroad runs from the mine, passing the Passaic Zinc Company's works and the New Jersey Zinc Company's mine, to the Midland railway, affording easy transportation.

Franklin Mines.—The *Hill* and *Furnace Veins*, at *Franklin*, continue

to be worked by the Franklin Iron Company. The *Hill Vein* mine has reached a depth of 190 feet in the shaft near the furnace. Very little work is done in that part of the vein, as it has become narrow in the bottom. A new opening further southwest than any of the present workings has shown a good vein of ore. The mining on this vein has demonstrated the existence of shoots and intervening pinches. The walls are of gneissic rocks. The ore is adapted to Bessemer metal.

The *Furnace Vein* is in the white crystalline limestone. It is worked northeast of the Wallkill. The principal slope is on the southwest point of Mine Hill, a few rods from the creek. It is 300 feet long, and descends on the foot-wall at an angle of about 60°. The workings in it have thus far opened three shoots, one above the other, and pitching towards the northeast. Between them the vein is narrow, or *pinches*. The horizontal drifts show very plainly these variations in size, as one goes from southwest towards the northeast. There are no clean, well-defined walls, but ore and limestone are mixed, and the mining stops where the latter predominates. They stand up firmly, and no timbering is necessary. At the bottom, Mr. Pierce, the manager, is driving westerly, and expects to strike the Hill vein. It will be interesting to ascertain the distance between these veins at the depth of 300 feet, as near the surface they are close together. The ore contains calcite, which assists as a flux in the furnace. The phosphorus is low. The product of these veins for the year is estimated by the manager to be 14,000 tons. Before the furnace was put in blast (July 5th) a little of the ore was sent to Scranton. At present it is smelted here, mixed with Tilly Foster, Combs, Baker, Spanish and other ores, for Bessemer metal.

Green's Mine.—This mine has not been worked in many years.

Bird's Mine.—This place was abandoned several years ago.

HEMATITE IRON ORES.

Radley Mine—Lebanon, Hunterdon County.—It is worked as a paint mine.

Nolf Farm.—A sample of specular ore from this place, on the Musconetcong Mountain, near the Delaware river, was taken from the surface and was analyzed. The analysis was as follows :

Metallic iron	39.07	per cent.
Sulphur	0.055	"
Phosphorus	0.039	"
Manganese	none.	
Titanium	traces.	
Insoluble in acid	43.60	"

The ore contains grayish-white quartz, mixed with the hematite, and is found in angular pieces in the soil. It occurs over an area of several acres. The quantity in the soil indicates the existence of strata or veins of mineral. The extent of the ore is about to be tested by the lessees of the property. The farm is less than a mile from the Durham furnace.

Marble Mountain.—This mine is on the southwestern point of Marble Mountain, Warren county. It has not been worked to any extent, and it has been idle for nearly twenty years.

Titman Shaft—Oxford Township, Warren County.—This locality is near Bridgeville. It is scarcely more than a locality of the mineral.

Ayers Farm.—A little hematite was found a few years ago on the Ayers farm, one mile southwest of Alamuche, Warren county.

Simpson Mine—Vernon Township, Sussex County.—No work has been done at this mine in a dozen years.

Cedar Hill Mine—Vernon Township, Sussex County.—The Ten Eyck, or Cedar Hill Mine (as it is sometimes called) has not been in operation since the Report of 1873.

Cooley's Mine—West Milford Township, Passaic County.—The work done on the Cooley farm, near Greenwood Lake, several years ago, was of the nature of exploration, and no considerable quantity of ore was obtained. The locality is of more interest geologically than economically.

Bird Mine—Union Township, Hunterdon County.—The Bird Mine has remained idle since 1873.

German Valley.—The searches in this valley have not been followed by any mining operations. The Report of 1872 referred at length to the explorations.

Wean Mine.—A notice of this mine appeared in the annual Report of the State Geologist for 1874. In the Report for 1878 it was reported to be yielding 90 tons per month, and an analysis of a sample received from Brewer, Mellick & Co. indicated a rich, good ore. The locality was visited during the season. It is interesting, geologically, as the country rock is a disintegrated gneiss. Mr. Hartpence, one of

the party who worked it, reports the deepest shaft as down 60 feet, and connected by a drift with another, 200 feet to the southwest. The ore appeared to be in pockets and irregular masses, and associated with yellow clays and ochre. About two-thirds of the ore was wash-ore, of bright red color. It was sold to paint works. The total product of the mine is estimated to have been 1500 tons. There is no water in the mine, and no pumps have been needed. The locality is so near to both the Central and the Lehigh Valley railroad stations that it has advantages of cheap transportation. The further opening is awaited with interest, as it is possible that the hematite may be connected with magnetite, although there are no indications of the latter ore, except the general fact of such ores occurring in the gneissic rocks.

Silver Hill.—Hematite has been found in several trial pits on lands of Wm. Carpenter, near the Lehigh Valley railroad, and on the northern foot of Silver Hill. It is in Greenwich township, Warren county.

Woolverton Farm.—This locality is on the west side of the Bloomsbury road, and two miles southwest of Asbury, Hunterdon county. A few holes have been dug in searching the ground, by the lessees—the Crane Iron Co.

Hazard Mine.—Hematite was mined at this place several years ago. It is on land of Chas. Hazard, and 1½ miles southwest of Asbury, in Hunterdon county. In the large heap of earth on the bank some very white and fine sandy clay, much like that found at Hulsizer's, near Stewartsville, was noticed. Also lumps of white quartzite were observed.

Shield's or Beattyestown Mines.—These mines are a short distance west of Beattyestown, Warren county, and on lands of Thomas Shields. The ore deposit appears to be one, although worked by different companies.

The northeast opening is that of the Thomas Iron Co. Work was stopped there about three years ago.

The next openings to the southwest are those of A. Pardee & Co., owners of the Musconetcong Iron Works. Of these, the eastern and old pit was 80 feet. The ore body was reported to be 10 feet wide at the bottom, and lying against a wall of blue limestone on the east. This pit was abandoned in the fall of 1877, and the working was transferred to a new pit about 30 yards further to the west. The depth of the present workings is about 60 feet. They are at least 400 feet long and about 80 feet wide. The stripping has been from 6 to 30

feet thick. The ore occurs associated with yellow clay, and is more in solid lumps than in the form of *bombs*. In places the working breadth has been 60 feet. The blue limestone is reached on the east and south-east sides of the pit. A slope extends from the washing works to the bottom of the pit, and the track runs thence to the south end of the opening. The water which is raised from it is used in washing. Of the whole amount mined, about ninety per cent. needs to be washed. A royalty of 45 cents per ton is paid to the land owner, and the cartage to the railroad depot at Hackettstown costs 50 cents. When visited, the production was about 1900 tons per month. It is shipped to Stanhope, and used in the furnaces of the Musconetcong Iron Works. The product for the past year is 9454 tons.

Adjoining this mine on the southwest, the same ore body was worked several years ago by the Boonton Iron Co. The openings are not deep nor extensive. It is reported that this property is to be re-opened by the Musconetcong Iron Works.

Carpentersville Mine.—This mine, near the mouth of the Pohatcong creek, and one mile south of Carpentersville, is not worked at present.

Hamlen Mine.—The Hamlen Hematite Mine is two miles east of Phillipsburg, near the Lopatcong creek, and on the farm of William Hamlen. The openings for ore were made several years ago. It was again worked for a short time in 1876. At the present time parties are digging yellow ochre for the Bushkill Paint Works, near Easton, Pa. The pit is approximately 200 feet long and 100 feet wide. The ochre is found on the east side of the ore deposit, and under it. It has a maximum thickness of 15 feet, and, in places, comes within 2 feet of the surface of the ground. The ore in this mine was found close to the surface. The water pumped out of the pit is used for washing the ochre.

Thatcher Mine, or Stewartsville Mine—Franklin Township, Warren County.—Work here stopped three or four years ago.

New Village, or Cline Mine.—The mine is idle.

Broadway.—The hematite locality near Broadway, Warren county has not been visited. There is no mining at the place.

Shiloh.—Of the hematite near Shiloh, *Hope township, Warren county,* there is no account of any recent opening or mining.

Swayze Mine—Hope Township, Warren County.—The mine is not in operation. It was fully described in the Report for 1877.

Van Kirk Farm.—Clarkson Bird, of Hamburgh, has recently opened a deposit of hematite on the Van Kirk farm, near the Ogdensburg and Sparta road, and about two miles from the former place. Of the probable extent of the ore, &c., nothing is known, as the place was not visited.

Scott Farm.—A brown hematite ore has been opened on lands of C. K. Scott, on the west foot of Pochuck Mountain, and two miles north of Hamburg, Sussex county. The deposit is reported to be small. A sample from the owner was examined, and found to contain of metallic iron 43.85 per cent.; of sulphur 0.84 per cent., and of phosphorus 0.021 per cent. A workable body of ore such as this analysis indicates would find a market.

Pochuck Mine.—The Pochuck Mine was at first worked as an open cut, and a large amount of ore was taken out. In 1873 a new slope was put down, and a gravity road was constructed to carry the ore to the railroad at McAfee Valley. Mining was actively carried on until 1876, since which date it has been idle. The mine has been an interesting geological locality, as the ore occurred in small lumps and masses in earths, and the ore-mass was bounded on the northwest and southeast sides by rotten gneissic rocks, which appeared to be true walls. These soft strata continued for over 100 feet in depth and 500 to 600 in length.

Edsall Mine.—This mine has been idle for many years. It is in Vernon township, Sussex county.

EXPLORING FOR NEW BEDS OF IRON ORE.

The demand for iron ore is constantly increasing, and this creates a very earnest inquiry for new and increased sources of supply. To answer this inquiry, there is an active search going on for other localities for mines; and increased facilities for transportation enable the searches to be carried into districts which have heretofore been so remote from market as to be worthless. The owners of old and established mines pursue their inquiries and searches with prudence and intelligence; but a great deal of money is wasted in useless or injudicious explorations by inexperienced and sanguine persons, who know the value of mines, but have not learned the difficulties of finding them. The following directions to those who are looking for iron ore deposits may be useful:

1. *The magnetic iron ore is always found in the Azoic rocks;* generally in gneiss, but in a few instances in the white crystalline limestones. It is not found in the blue limestones, or slates or sandstones; neither is it found in the trap rocks, though there is very strongly developed local attraction observed on the surface over many of the rocks of this kind. There is disseminated through the rock a little magnetite and metallic iron, but it is probably not one per cent. of the whole, and not enough to be of any commercial value; so that the search may be limited to the rocks above mentioned.

2. *The magnetic iron ore is all in beds interposed between the layers of the gneiss, and conformable to them.* It is never in veins which cut across the layers of the rock; it has no gangue rock of calc spar, fluor spar, quartz, or any other mineral different from the common minerals of the adjacent rock layers; it has no rock walls by which the ore is separated from the adjacent rock, which at all differ from any other two adjoining beds of rock which are separated by a seam of softer or otherwise different mineral, and in many cases there is no seam at all, but the ore adheres firmly to the rock; and in many instances it passes into rock by a gradual diminution of magnetite in the mass. These

beds of magnetite, like the rocks among which they occur, are highly inclined or almost vertical. In this respect they have an accidental resemblance to true veins, which has led to their being commonly called by that name; and if the word vein means only a flattened mass of ore standing on edge, it is properly applied to these beds of ore.

3. *The beds of ore come to the surface of the rock in almost all cases*, so that it is only needful to remove the covering of earth and the bed of ore can be seen. These beds of ore are not continuous like the layers of rock, though interposed between them, but are of limited extent. The outcropping edges of the beds may extend along between the layers of rock for from 10 to 1000 or more feet, and of a breadth varying from a few inches up to twenty feet or more. The most common direction in which these beds extend is from southwest to northeast, and at their extremities they sometimes thin out to nothing; and in other cases they grow leaner and are replaced by rock. They usually dip down steeply towards the southeast, and at their extremities the ore, instead of descending straight down the slope, slants off or *pitches* towards the northeast. It is remarkable that the beds of ore which outcrop for a considerable distance have frequent narrowings and widenings, and these narrow or wide places in the veins *pitch* towards the northeast just as the extremities of the bed do. Some beds have been worked to their termination at the bottom, but most of the large beds show no apparent diminution.

Such being the mode of occurrence of the ore, it is only necessary to remove the loose earth, in order to determine whether the ore is there. Blasting out or sinking expensive shafts in rock is not necessary, and such expense should not be incurred in ordinary explorations.

4. *The direction in which the beds of ore range* is the same as the strike of the rock, and the extension of worked beds of ore is frequently proved by ranging, and many successful searches for *new* openings upon ore have been made in this way. In some cases, however, the rock has curves in the stratification, and then the ore veins curve with it.

5. *In ordinary cases, where the surface is covered with loose earth, it is common to search for ore with a magnetic needle or a miner's compass*, and for preliminary examinations it is now the chief reliance. In using this instrument much practice is required; but this joined to

good judgment gives indications of the presence of ore which are almost infallible.

There has been very great improvement, within a few years past, in the methods of searching for magnetic ore, as well as in the instruments to be used for that purpose, and the work is now well done by many persons. But as there are still many others who are not familiar with the methods or instruments, we again repeat them here, varying only as experience has shown to be desirable, from the directions given by the late Dr. Wm. Kitchell, in his annual Report on the Geological Survey of New Jersey for 1855, pp. 236–7–8; in the "Geology of New Jersey" of 1868, pp. 535–9, and in the annual Report on the Geological Survey for the year 1873, pp. 90–97. Maps, locating and recording the attractions accompanied the latter report. This year, with the directions again given, we present a map of a magnetic survey made at Oxford, Warren county, by W. H. Scranton, M. E., to determine the location of a vein, and the proper places to sink shafts. The work is admirably done, and it is hoped that the study of the map and the practice of the directions here given will help to increase the number of intelligent men who search judiciously for iron ore.

SURVEY OF THE WASHINGTON MINES AT OXFORD, BY W. H. SCRANTON, M. E.

"I inclose the map herewith, and would say, in explanation of the system used, that a line is first ranged out over the centre of the vein as nearly as it can be determined, by a rough examination with the dipping compass. This ranged line then becomes the centre line of the *survey*, whether it corresponds with the 'centre of the vein' or not. On this line stations are to be measured off, say 50 feet apart. Each station should be marked with a stake, and each stake numbered, to avoid subsequent errors.

"On the accompanying map the centre line is drawn heavier than the others. The stations are located fifty feet apart, and are marked respectively 0, 50, 100, 150, etc., up to 1750 feet, the limit of the survey.

"In making field-notes, I find it convenient to use topographical paper on which the squares of one inch are ruled with red lines, and those lines subdivided into fifths by blue lines; the intersections of

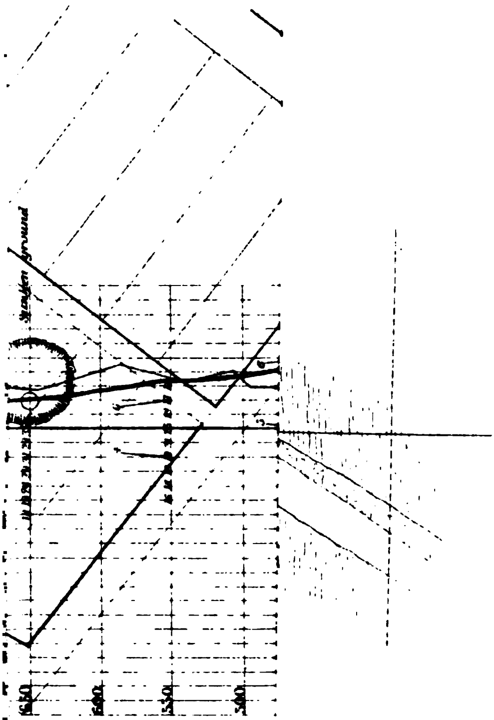
F THE WASHINGTON

NEW JERSEY.

BY

SCRANTON,

CT. 1879.



BIEN, LITH. N.Y.

the red lines correspond to fifty feet, and those of the blue lines to ten feet.

"Having first marked off the stations of the centre line of the sheet to correspond with those of the centre line of the survey, commence at any station and note the dip indicated by the compass, record it on the centre line of the sheet at the proper station; then, moving to the right of the centre line ten feet, and at a right angle with it, note the dip and record it on the first blue line to the right of the station on the paper. In this way make and note these observations every 10 feet, both to the right and left of the centre line, as far as may be desired.

"In the same way, record the *variation* of the horizontal needle. I find a small solar compass most convenient for this purpose. The neutral line of the vein (marked by a double black line), determined in this way, corresponds *very nearly* with the actual centre of the vein, as you will notice by the cross section, A B, on the accompanying map. The section is taken at A B on the plan. The veins (of which there are two, in contact with each other) are inclined at an angle of about 60°. The centre line determined on the surface (shown by a vertical line) passes through the centre of the vein at about 70 feet from the surface, and the ore commences at 40 feet from the ground. You will notice a zigzag line extending from one shaft to the other. This is a transit line run through the heading at varying levels; it passes through several centre stations, and corresponds very nearly with the neutral line, proving that considerable reliance can be placed on this method of determining the centre of the vein.

"The sheet of cross-section paper, when filled, becomes at once *a map* from which to draw deductions. For instance, the neutral line is determined and can be readily marked on the ground from the stations of the centre line of the survey. So can all the points of heaviest attraction. By drawing lines through the stations of heaviest dips, areas including the strongest attraction are determined, as shown on the map, where such lines are drawn through the dips of 53°, (this number was selected as being 10° more than is found on any part of the *developed* vein) indicating two places on the vein, of appreciable extent, that are considerably more magnetic than the rest of it. Within these lines is evidently the proper place to sink. It would seem, from the magnetic indications that two shoots of ore are thrown up

at this point, and that at the highest point of dip, near the centre of each of these, is the heaviest body of ore.

"I find Gurley's Norwegian compass the best, though the slowest to work with."

"The indications from the magnetic needle, in searching for ore, as it usually occurs in our State, are as follows:

"An attraction which is confined to a very small spot and is lost in passing a few feet from it, is most likely to be caused by a boulder of ore, or particles of magnetite in the rock.

"An attraction which continues on steadily in the direction of the strike of the rock for a distance of many feet or rods, indicates a vein of ore; and if it is positive and strongest towards the southwest, it is reasonable to conclude that the vein begins with the attraction there; if the attraction diminishes in going northeast, and finally dies out without becoming negative, it indicates that the vein has continued on without break or ending until too far off to move the compass needle. If, on passing towards the northeast, along the line of attraction, the south pole is drawn down, it indicates the end of the vein or an offset. If, on continuing farther still in the same direction, positive attraction is found, it shows that the vein is not ended; but if no attraction is shown, there is no indication as to the further continuance of the ore.

"In crossing veins of ore from southeast to northwest, when the dip of the rock and ore is as usual to the southeast, positive attraction is first observed to come on gradually, as the ore is nearer and nearer to the surface, and the northwest edge of the vein is indicated by the needle suddenly showing negative attraction just at the point of passing off it. This change of attraction will be less marked as the depth of the vein is greater, or as the strike is nearer north and south. The steadiness and continuance of the attraction is a much better indication of ore than the strength or amount of attraction is. The ore may vary in its susceptibility to the magnetic influence from impurities in its substance; it does vary according to the position in which it lies—that is, according to its dip and strike; and it also varies very much according to its distance beneath the surface.

"*Method of Using the Compass in Searching for Ore.*—It is sufficient to say that the first examinations are made by passing over the ground with the compass, in a northwest and southeast direc-

tion, at intervals of a few rods, until indications of ore are found. Then the ground should be examined more carefully by crossing the line of attraction at intervals of a few feet, and marking the points upon which observations have been made, and recording the amount of attraction. Observations with the ordinary compass should be made, and the variation of the horizontal needle be noted. In this way materials may soon be accumulated for staking out the line of attraction, or for constructing a map for study and reference.

"After sufficient exploration with the magnetic needle, it still remains to prove the value of the vein by uncovering the ore, examining its quality, measuring the size of the vein, and estimating the cost of mining and marketing it. Uncovering should first be done in trenches dug across the line of attraction, and carried quite down to the rock. When the ore is in this way proved to be of value, regular mining operations may begin.

"In places where there are offsets in the ore, or where it has been subject to bends, folds or other irregularities, so that the miner is at fault in what direction to proceed, explorations may be made with the diamond drill."

1. In the application of the above-mentioned directions, or rules, it is advisable to consult the geological map of the State to ascertain the extent and location of the Azoic rocks. The small map accompanying this report shows the boundaries of the rocks.

2. The effects of the glacial drift are also to be considered. The southern limit of that formation is indicated on the State map. Over all of the country lying north of that line the original surface has been modified by the great continental glacier which moved over it. The rock outcrops have been ground down, grooved and polished, and, in part, covered by earth, gravel, cobblestones and boulders, which have been pushed along by the ice. These deposits, lying upon the abraded strata, are of two kinds: one is unstratified; the other has its materials sorted, and in layers. But in both cases the materials differ from the underlying rock strata. They represent the rocks from the outcrops to the northward, and have been gathered from the district over which the ice moved. Hence, north of this glacial drift or moraine line the boulders and gravel found in the earth are not always characteristic of the strata under it. There may be fragments of hematite, or of magnetic iron ore, or of zinc ores, which have traveled

several miles from the parent ledges. The boulders of franklinite common in the drift-bank and moraine at Ogdensburg, in Sussex county, have come from Mine Hill, Franklin, and others of them have been found some miles farther southwest. It is not safe to draw conclusions from boulders.

South of the terminal moraine line there has not been any such abrasion of the surface, nor such accumulations of unsorted drift. The strata have been exposed to the longer and more gentle action of atmospheric agencies, as frosts and rains. These working throughout the long geological periods, have disintegrated the rocks and changed them, in many cases, into earth-like masses, sometimes termed *rotten rock*. The earthy covering is here derived from the rocks in place, and, excepting what may have washed from hill sides above, represents the underlying strata; and the rocks in it may serve as a guide in searches for ore. These are sometimes known as float ore,* and are good indications. On account of the great depth to which this disintegration has in some places reached, it may be necessary to sink many feet to test ground thoroughly and to reach the harder strata, although the lines of bedding may be seen in the rotten rock and earth quite near the surface. It appears as if there was in this fact of the drift an explanation of the greater number of early locations of mines in the northern, rather than in the southern parts of our Highland range. The disintegration in the latter has crumbled the original ledges, and concealed them beneath their own debris. Further to the north, the ice-polished ledges have not been so long exposed to the action of the elements, and they stand out plainly wherever they are not covered by drift. Attention to these differences in the nature of the over-lying earths and of the undisturbed strata, will enable the careful prospecter to search more intelligently and more successfully. In using the compass, the same precautions are advisable. A great thickness of earth may prevent the tracing of the line of attraction, or a great variation in it from point to point may, in part, account for varying intensity in the attraction. Large boulders of magnetic iron ore in glacial drift may affect the needle, and give a very irregular and unsteady attraction. In general, it may be said that there is greater need of careful attention to the indications in a drift-covered district or area, than in

* The term *float ore* is occasionally used to designate any loose ore on the surface. When in glacial drift, it may be boulders.

one not so covered. Some remarkable examples of inattention to the indications of the surface earths, and failures to find workable veins of ore, could be given, if they were not at once apparent to all who are familiar with the iron ore district.

3. The value of the compass as a guide in searching for magnetic iron ores has been so frequently proved in the discovery of veins of ore and the opening of large and profitable mines, that it is unnecessary to give examples. The Geological Survey has accumulated a large amount of material in this direction. And in a future report it may be desirable to put together the records of surface indications and the developments, and show how far they correspond with one another. A more careful survey, and the construction of an accurate map of the iron-ore district ought to give us a clew to the geological structure, and indicate the *ore-bearing belts or ranges*, as distinguished from barren areas. At present the compass is our best guide over the whole district.

SEARCHING FOR HEMATITE.

The brown hematite mines in our State are either on the line of the gneissic and magnesian limestone rocks, or along the border of the latter and the slate. And searches should be directed along these geological boundaries. Yellow and yellowish-white clays and ochrey earths accompany this ore, and they are good indications. The compass cannot be used. But the same examination of the overlying earths and stones in the soil is more important in looking for this than it is in searching for magnetic iron ore. The fragments of ore among the stone or gravel of the surface may have been carried by ice from ledges miles away. Such indications would be altogether misleading. The first inquiry should be as to the nature of the earth or surface covering. If on a slope, the ore may have washed down hill from a deposit above; or, if in a smooth valley, where the earth is stratified with sand and gravel, it may have been carried a long distance by streams or floods of water coming from the melting of the glacier ages ago. The occurrence of hematites in these diluvial strata, as for example in the gravels of Succasunna Plains, Morris Plains and the flats along the Pequest creek and other streams, indicates the existence of such ores whence these materials come, and not necessarily in the locality where they are found. The frequency and quantity

may enable one to trace them to their source—*to follow up the old stream.* In contrast to the magnetic iron ores, the hematite mines of our State are mostly south of the glacial drift, although the extent of country in which searches are to be made south of that limit is less than that to the north of the same. The glacial drift, as also the terrace drift, has so altered the surface as to conceal more effectually the few deposits which may have escaped the grinding force of the glacial ice.

6. THE SOILS OF NEW JERSEY.

The soil is that surface coating of the earth which is capable of supporting vegetation, and, when cultivated, of producing crops. It is usually but a few inches in thickness, and is always characterized by containing a little decaying vegetable matter which gives it a color somewhat darker than the earth or subsoil under it. It also differs from the subsoil in its consistency, being more mellow and crumbling.

And yet, however different the soil from the subsoil under it, both are derived from the same materials, that is, from the rocks underlying them, or from the sands, gravels and clays upon those rocks. The difference has been produced by the long-continued action of air and moisture, the varying temperatures of the year, and the action of the growing and decaying vegetation upon the mineral subtances of the earth or rock surface. It is only necessary to examine a pile of earth, crumbled rock, or even of cinders or broken bricks, which has been exposed to the weather for a few years, and the beginnings of a soil will be seen—fine particles have gathered in protected places, weeds, grass, and perhaps trees have begun to grow in it, and it is taking the dark color and mellow consistency of a soil. And this change will go on until the coating of soil is so thick that the agencies of change can no longer act. Soils made in this way can be seen on the embankments of any of our older railroads or canals. There is a bank near New Brunswick made about forty years ago, entirely of red shale, which now has the mold or soil on it from two to four inches deep, and is covered with grass, bushes and some trees. The cinder heaps at Oxford which may be fifty or sixty years old, have some large trees on them, grass is growing in patches, and they promise to be soon entirely covered with soil. In looking at the cut edge of any excavation the several layers of soil, subsoil and underlying rock or earthy material are plainly seen, and the change from one to the other may be examined and understood. The nature of the changes which the underlying rocks or earths have been subjected to are various. In the granitic and crystal-

line rocks there has been a decomposition by which the feldspar has become clay, the quartz is sand, and the mica or hornblende is a more or less reddish sandy earth. On the limestone rocks, the soil has been made by the slow dissolving of the carbonate of lime in water, and leaving as a sediment the original impurities of the rock to cover the surface and constitute a soil. Slates crumble down fine and make a clayey soil with very little chemical change from the original rock. Other kinds of rock, by their crumbling or decay, produce soils of different qualities.

As soils, then, are formed from rocks, they must necessarily have some qualities in common with the rocks, and in any particular district or country the easiest and most systematic classification of soils is based on its geological structure.

The designation of soils as sandy, loamy, or clayey is common in all countries, and conveys some idea of their consistency, but it is merely a comparison of soils on the same farm or in the same neighborhood. As applied in different parts of New Jersey the terms are very inaccurate; that which is called a clayey soil in the southern end of the State, would be called a sandy soil at the north. Such a classification also gives no information as to the composition or capabilities of a soil. On the contrary, a classification of soils based on their geological origin does give some idea of the nature and promise of the soil, even if its surface materials have been sorted by rains, so as to leave it more sandy in some places, and more clayey in others.

The classification we shall use for the description of the soils of the State is one based on their geological origin, as follows:

1. *Granitic*—The soils on the Azoic rocks, and which have evidently been formed from the decomposition or disintegration of the gneiss hornblende and granite rocks of this formation. They are designated on the map by a crimson or carmine color.

2. *Limestone*—The soils which overlie the white, magnesia, and Helderberg lime-rocks, and have been formed from these rocks by the solution and removal of most of the lime, leaving the earths and impurities of the stone for the soil. Each of these soils and rocks is designated by a blue color.

3. *Slate*—The soils which are on the Hudson river slate, the Oriskany sandstone, and the Cauda-galli grit, and have been formed by the

simple disintegration of those rocks. These soils are usually more or less clayey. They are colored on the map of a neutral tint.

4. *Red Sandstone and Shale.*—These soils have been formed by the disintegration of the rocks on which they are found. The color on the map shows their location.

5. *Trap*—Is the soil which is formed by the decomposition of trap-rocks, and is found on them. An olive-green color is used on the map to designate this soil.

6. *Clay and Sand*—Designates the soils which are found on the outcrop of the formations of white clays and sands of the lower member of the Cretaceous period. These soils are designated by a yellowish color.

7. *Marl Soils*—Are those which are on the outcrops of the clay marls, lower marl bed, red sand, middle marl bed, yellow sand, and upper marl bed. They are formed by the mixing together of these different strata. On the map they are colored different shades of green.

8. *Silicious Soils*—Include all those in which quartz ore or silicious matter largely predominates. They are designated on the map by a yellow color of different shades, and the following subdivisions are distinguished:

a. Quartz-rock—Soil which is on the conglomerate of the Green Pond Mountain, and on the Oneida conglomerate and the Medina sandstone of the Kittatinny Mountain. These lands are all in forest.

b. Pine-land—That soil which is found in portions of Southern New Jersey, and on which *only* yellow pine ever grows. It is formed from the glass-sand and the water-sorted, gravelly earth.

c. Oak-land—That soil which is found in portions of Southeastern New Jersey, and on which oak timber grows. It is the unsorted gravelly earth of the Post-Tertiary Age.

d. Miocene—The soil found on the miocene marl of Cumberland county.

9. *Glacial-drift Soils*—Are designated on the map over all the northern part of the State by small black dots. These soils are somewhat like the rocks on which they lie, but their composition is changed by the addition of earth brought by the glaciers from the rocks farther north.

10. *Alluvial*—Is the name given to the soils which make the tide marshes—those which are along the borders of the uplands and only

a few feet above tide-level, and also to those which make up river flats. They are designated to some extent on the map by fine-ruled black lines.

Samples of all these varieties of soils have been collected, and as many as the other work of the laboratory would allow of, have been analyzed. The analyses have been made by digesting in acids, and not by fusion. From an extensive acquaintance with the farms and farming of all parts of the State, it is believed that these analyses are in accordance with the results of farm practice, and that they may be studied and used with profit.

ANALYSES OF SOILS.*

Granitic Soils.

	Water. (Moisture.)	Sand. (Insoluble in acid.)	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Carbonic Acid.	Organic Matter	Total.	Nitrogen.
1 Soil— Chester, Morris county......	2.100	77.100	7.820	3.580	1.160	0.080	0.301	0.230	0.021	....	0.055	7.000	99.447	0.194
2 Subsoil— Flanders, Morris county....	2.300	63.300	16.490	9.200	0.252	0.070	0.041	0.198	traces	traces	....	8.500	100.351	0.044
3 Soil— Washington, Warren co....	1.550	72.250	19.573		0.312	0.130	0.014	0.127	0.005	0.002	0.019	5.850	99.832	0.034
4 Soil— Pohatcong Mt., Warren co.	2.000	63.800	16.150	8.840	0.504	0.190	0.120	0.154	traces	0.017	0.014	8.850	100.640	0.022

Limestone Soils.

	Water. (Moisture.)	Sand. (Insoluble in acid.)	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Carbonic Acid.	Organic Matter	Total.	Nitrogen.
5 Soil—Wm. Shields, New Hampton..................	1.900	77.350	7.959	4.175	0.792	0.450	0.548	0.174	0.031	....	0.250	6.350	99.979	0.118
6 Soil—Wm. Shields, New Hampton..................	1.850	79.400	7.209	4.124	0.720	0.235	0.540	0.191	0.027	....	0.117	5.500	99.913	0.130
7 Soil—Wm. Shields, New Hampton..................	1.800	79.450	7.370	3.520	0.756	0.505	0.475	0.160	0.031	....	0.082	5.850	99.999	0.153
8 Soil—Oliver Kline, Musconetcong Valley........	1.450	82.050	6.547	5.037	0.432	0.215	0.250	0.115	0.014	....	0.097	3.600	99.807	0.094
9 Soil—Oliver Kline, Musconetcong Valley........	1.700	79.200	7.545	4.590	0.796	0.470	0.306	0.115	0.021	....	0.079	5.350	100.171	0.132
10 Soil—W. H. Drake, Musconetcong Valley........	1.900	81.550	6.181	3.715	0.918	0.372	0.363	0.154	0.026	....	0.097	5.150	100.426	0.134
11 Soil—Robert L. Smith, Bloomsbury....................	1.900	74.650	8.730	4.560	0.540	0.470	0.329	0.160	0.024	....	0.061	8.250	99.674	0.206

*The analyses were made by digesting the soils in acids, and not by fusion.

ANALYSES OF SOILS—(CONTINUED.)

		Water. (Moisture.)	Sand. (Insoluble.)	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Carbonic Acid.	Organic Matter	Total.	Nitrogen.
12	Soil—Robt. I. Smith, Bloomsbury	1.200	79.900	7.379	4.817	0.514	0.343	0.362	0.141	0.027	....	0 065	5.350	100.098	0.120
13	Subsoil— Johnsonburg, Warren co.	1.400	70.160	3.877	5.016	0.576	0.240	4.235	0.307	traces	traces	5.380	8.050	99.241	0.131
14	Soil—John T. Leigh, Clinton	1.550	79.500	7.195	3.555	0.763	0.075	0.371	0.166	0.027	....	0.132	6.550	99.884	0.176
15	Soil—Robert Craig, New Germantown	2.200	77.200	7.149	6.219	0.343	0.140	0.453	0.282	0.015	....	0.823	5.550	100.374	0.107
	Slate Soils.														
16	Soil— Deckerton	0.750	76.050	10.888	5.534	1.638	0.250	0.072	0.128	0.005	....	....	3.700	99.015	0.069
17	Soil—Wm. P. Nicholas, Newton	1.400	74.100	8.837	5.175	1.850	0.650	0.618	0.288	0.012	....	0.082	6.350	99.362	0.130
18	Soil— Asbury, Warren county	1.950	75.300	7.410	6.826	1.152	0.220	0.059	0.064	0.010	....	0.054	7.050	100.095	0.131
	Red Sandstone and Shale Soils.														
19	Soil—John T. Leigh, Clinton	1.250	83.250	5.673	4.641	0.306	0.155	0.140	0.086	0.017	....	0 048	4.250	99.816	0.095
20	Soil— Kingwood, Hunterdon co.,	2.750	75.550	9.318	2.504	0.605	0.120	0.067	0.077	0.019	....	0.024	8.950	99.984	0.182
21	Soil— College Farm, N. Brunsw'k	3.000	83.400	3.311	2.044	0.180	0.090	0.018	0.046	0.024	....	0.055	7.200	99.368	0.119
22	Subsoil— Under No. 21	1.300	88.600	3.991	2.575	0.324	0.015	0.003	0.034	0.011	....	0.018	8.500	100.366	0.048

23	Soil— College Farm, N. Brunsw'k	1.900	80.500	6.495	4.472	0.468	0.325	0.221	0.083	0.029	....	0.032	5.600	100.125	0.161
24	Subsoil— Under No. 23..................	2.075	84.150	3.944	5.096	0.576	0.270	0.189	0.060	0.021	....	0.012	4.125	100.518	0.053
25	Soil— Commons, New Brunswick	3.80	71.070	9.260	6.560	2.020	0.810	0.220	0.140	0.030	....	....	5.000	98.910	0.074

Trap Soils.

26	Soil— Palisades Mt., Bergen co...	3.700	76.300	6.186	8.510	0.288	0.145	0.140	0.089	0.004	0.012	0.150	4.750	100.274	0.041
27	Soil— Washington Rock......	6.800	52.100	16.310	13.512	1.600	0.125	0.357	0.078	0.008	....	0.012	8.550	99.452	0.041
28	Soil— Mt. Horeb, Somerset co.....	4.150	70.250	7.790	9.672	1.512	0.150	0.268	0.038	0.012	....	0.005	6.410	100.257	0.054
29	Soil—Ten Mile Run Mountain, Middlesex county......	3.250	52.200	23.050	11.320	0.304	0.190	0.120	0.077	traces	0.020	0.025	9.500	100.056	0.023
30	Soil— Rocky Hill, Mercer co......	1.650	72.200	18.370		0.302	0.130	0.100	0.131	0.014	traces	0.029	7.000	99.926	0.051

Marl Soils.

31	Soil— Holmdel, Monmouth co....	1.700	88.450	1.668	4.677	0.360	0.470	0.029	0.205	0.010	....	0.010	3.500	101.079	0.069
32	Soil— Edinburgh, Monmouth co..	1.400	86.250	2.397	6.968	0.108	0.076	0.016	0.186	0.034	....	0.008	2.400	99.843	0.026
33	Soil (No. 1)— Thorofare, Gloucester co...	0.400	96.050	0.904	0.860	0.065	0.095	0.105	0.106	0.024	....	....	1.330	99.940	0.053
34	Soil (No. 2) Thorofare, Gloucester co....	0.450	94.200	0.624	1.080	0.132	0.133	0.110	0.096	0.027	....	....	3.600	100.450	0.085

Silicious Soils.

35	Soil— Shiloh, Cumberland co......	2.00	83.10	5.45	2.25	0.74	0.19	traces	0.05	traces	....	....	6.60	100.38	0.114

ANALYSES OF SOILS.—(CONTINUED.)

Oak-land Soils.

	Water. (Moisture.)	Sand. (Insoluble.)	Alumina.	Oxide of Iron.	Magnesia.	Potash.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.	Carbonic Acid.	Organic Matter	Total.	Nitrogen.
36 Soil— Bricksburg, Ocean county..	0.214	97.050	0.774	0.312	0.058	0.042	0.019	0.015	0.002	....	0.011	1.146	99.643	0.025
37 Soil—Chas. H. Irons, White Oak Bottom, Ocean co......	0.600	94.200	2.344	1.130	0.018	0.038	0.021	0.026	0.010	....	0.010	1.400	99.797	0.039
38 Soil—White Oak Bottom, Ocean county.........	1.500	89.250	4.797	2.014	0.216	0.080	0.015	0.084	0.005	trace	0.017	2.300	100.278	0.035
39 Soil—George W. Cowperthwaite, Toms River.........	0.350	94.300	1.070	1.400	0.252	0.040	0.021	0.031	0 021	0.002	....	2.150	99.640	0.042
40 Subsoil— Under No. 39..................	0.450	92.450	1.814	1.966	0.200	0.045	0.014	0.020	0.012	....	....	2.250	99.220	0.028
41 Soil—East of Whiting's, Ocean county.................	0.250	94.500	1.705	1.870	0.114	0.025	0.007	0.025	traces	traces	0.017	1.650	100.160	0.027
42 Subsoil—Cedar Bridge Road, Ocean county..................	1.150	83.180	8 375	3.099	0.076	0.055	0.005	0.026	0 0014	0.0017	....	3.950	99.921	....
43 Soil— Egg Harbor City............	0.225	96.160	1.206	0.796	0.056	0.036	0.011	0.019	0.0008	traces	....	1.375	99.885	0.018
44 Soil— Weymouth Road, Vineland	0.550	91.900	2.124	3.399	0.126	0.055	0.025	0.077	0.015	....	0.012	1.850	100.133	0.037
45 Soil—Dr. T. T. Price, Tuckerton......................	0.300	97.460	0.427	0.230	0.014	0.033	0.012	0.023	0.0017	traces	....	1.500	100.000	0.015
46 Soil— Mauricetown..................	0.850	94.440	2.489		0.050	0.040	0.017	0.031	0.0007	0.0018	....	1.975	99.890	0.080

Pine-land Soils.

47	Soil— Bricksburg tract...............	0.100	98.910	0.293	0.087	....	0.001	6.0017	traces	traces	traces	....	0.700	100.093	....
48	Soil—Dillon's Island, Toms River.........	0.250	98.590	0.212	0.248	trace	trace	trace	trace	traces	trace	....	0.650	99.950	0.017
49	Soil—Two miles south of Toms River....................	....	99.420	0.318	0.024	0.010	0.014	trace	0.018	trace	....	....	0.200	100.000	....
50	Subsoil— Under No. 49..................	0.500	98.120	0.472	0.510	0.011	0.007	0.018	0.028	....	traces	traces	0.250	99.916	0.014
51	Soil— East Plains......................	0.200	98.440	0.269	0.452	traces	0.035	0.025	0 038	0.0007	0.0005	....	0.200	99.660	....
52	Subsoil— Under No. 51..................	0.200	97.020	0.663	0.792	0.054	0.031	0.012	0.045	0.017	traces	....	1.050	99.884	....

Alluvial Soils.

53	Soil— Greenwich, Cumberland co.	1.60	86.50	1.56	2.13	0.47	0.16	0.31	0.154	0.02	traces	....	6.65	99.69	0.203
54	Soil—Downes Edmonds, Cape May.........................	0.80	90.95	2.47	0.82	0.29	0.18	0.53	0.06	0.08	traces	....	3.40	99.58	0.134

Of the soils in the above list, No. 11 may be taken as the model of naturally good soil. It is the virgin soil of the limestone valleys of Warren and the adjoining counties. These valleys have now been cleared and in cultivation for more than a hundred years, and they have always been noted for yielding large crops of wheat, rye, corn, and clover. Soil like this will yield 30 bushels of wheat to the acre, without any manure or other fertilizer. After these soils had been cropped for a good many years, it was found that an occasional crop of clover was essential to keeping up the fertility of the soil. And the practice of the farmers there is now to crop their lands in a four years' rotation, of clover, corn, fallow or oats, wheat, and then clover again, and to dress the ground before sowing wheat with a coat of fresh-slaked lime. Good crops are obtained in this way, but whenever the clover crop fails, the wheat, too, is a failure. Three or four such failures have recently occurred there; and this led to the analysis of the cultivated soils 7, 8, 9, 12, which were originally the same as 11, The only difference to be seen is in the amount of nitrogen in the soils. and this is no doubt the chief cause of the failure. The Hessian fly has been very troublesome there, but the soils rich in nitrogen withstood its attacks. The last season the crop of clover was better, and it is reported that the promise for wheat is good. It would be an improvement to lengthen the rotation by keeping the land in clover, or clover and timothy, two years instead of one, and so increasing the amount of nitrogen in the soil. This would allow of keeping twice as large a stock of cattle and sheep as is now kept, and of course of making twice as much nitrogenous manure. And four-fifths as much land as is now sown in wheat would be sure to produce more wheat than the whole now does. The land contains a store of lime, potash, and phosphoric acid, that is practically inexhaustible. All that is needed in the soil is a sufficient quantity of vegetable or other organic substance containing nitrogen, to make these mineral substances soluble.

The soils 31 and 32 are good examples of soils deficient in some essential constituents, while having others in abundance. These soils, when first cleared, would raise good crops of corn and rye, but wheat was not grown. Lime applied to them will cause them to bring good crops of clover, and with that fine crops of wheat can be grown; and the country where these soils are found, by skillful management is made to produce much larger aggregate returns from its farms than are at

present obtained in those like Nos. 5–11. The soils of this kind have, however, been still further improved by the use of greensand marl. But even with this, the lime and clover are still necessary.

An examination of the analyses of soils from different agricultural districts of the State will help the experienced farmer to judge of the deficiencies of his own soil, and may furnish hints for its improvement. But the analyses give no indication of the physical condition of the soil. It may be flat in its surface, and illy drained, or may have a close subsoil; in which cases, however rich it may be in all the constituents of a good soil, it will not yield good crops. For example: the soil 20 is a rich one, and it is covered with very heavy timber, but it is cold and wet, and can only be made fit for profitable tillage by being thoroughly and deeply underdrained.

The soils of the oak-lands of southern New Jersey are comparatively deficient in the elements which make a naturally fertile soil, and when first cleared they produce only very light crops of corn and rye, but when properly fertilized with marl or other manure, they can be made very productive. Excellent farms are to be found in various places on these lands, and the smaller cost of cultivation goes far to compensate for the extra cost for manures. Of these lands there is a large area which is still unimproved, waiting for enterprising and industrious settlers to locate on it. The means by which these soils can be easiest brought into productive cultivation were shown in last year's report, and as the subject is one of continued interest, the matter is repeated here.

The chief constituents of a fertile soil which are liable to be soon exhausted, are vegetable or other organic matter containing nitrogen, lime, potash, and phosphoric acid. The first table below gives the number of pounds per acre of each of these constituents in the various soils analyzed. The second and third tables show the amount of the mineral substances taken out by a five years' rotation of good farm crops. An inspection of the table shows that a very few years of cropping would be sufficient to entirely exhaust some of these soils of their fertilizing constituents if the crops were all sold off the farm.

1.—Number of pounds per acre of potash, lime, phosphoric acid and nitrogen, in various soils.

Granitic Soils.

		Potash, Pounds.	Lime, Pounds.	Phosphoric Acid, Pounds.	Nitrogen, Pounds.
1	Natural soil, woodland, Chester, Morris county	1,393	5,226	4,006	3,380
2	Subsoil, Flanders, Morris county	1,305	713	3,450	767
3	Uncultivated soil, Washington, Warren county	2,242	200	2,190	592
4	Uncultivated soil, Pohatcong Mountain, Warren Co.	3,276	2,069	2,656	383
	Limestone Soils.				
5	Soil, cultivated, Wm. Shields, Musconetcong Valley, Warren county	7,839	9,546	3,031	2,055
6	Soil, cultivated, Wm. Shields, Musconetcong Valley, Warren county	4,093	9,400	3,484	2,264
7	Soil, cultivated, Wm. Shields, Musconetcong Valley, Warren county	8,797	8,274	2,787	2,665
8	Soil, cultivated, Oliver Kline, Musconetcong Valley, Warren county	3,745	4,355	2,003	1,638
9	Soil, cultivated, Oliver Kline, Musconetcong Valley, Warren county	8,187	5,330	2,003	2,300
10	Soil, cultivated, W. H. Drake, Musconetcong Valley, Warren county	6,480	6,323	2,683	2,334
11	Soil, virgin, Robert I. Smith, Bloomsbury, Warren county	8,187	5,731	2,787	3,588
12	Soil, cultivated, Robert I. Smith, Bloomsbury, Warren county	5,975	6,305	2,456	2,090
13	Subsoil, Johnsonburg, Warren county	4,180	73,702	5,348	2,282
14	Soil, John T. Leigh, Clinton, Hunterdon county	1,306	6,462	2,891	3,065
15	Soil, Robt. Craig, New Germantown, Hunterdon Co.	2,439	7,891	4,913	1,864
	Slate Soils.				
16	Soil, natural, William S. Vanderuff, Deckertown, Sussex county	4,350	1,256	2,230	1,213
17	Soil, cultivated, William P. Nicholas, Newton, Sussex county	11,323	10,766	5,017	2,264
18	Soil, natural, near Asbury, Warren county	3,832	1,028	1,115	2,282
	Red Sandstone and Shale Soils.				
19	Soil, cultivated, John T. Leigh, Clinton, Hunterdon county	2,700	2,439	1,498	1,655
20	Soil, natural, Kingwood, Hunterdon county	2,090	2,211	1,341	3,170
21	Soil, natural, College farm, New Brunswick	1,568	226	801	2,073
22	Subsoil, under No. 21	261	52	592	837
23	Soil, cultivated, College farm, New Brunswick	5,661	3,849	1,446	2,805
24	Subsoil, under No. 23	4,703	3,293	1,045	923
25	Soil, uncultivated, unfenced commons	14,110	3,832	2,439	1,289
	Trap Soils.				
26	Subsoil, natural, Palisade Mountain, Bergen county	2,526	2,438	1,560	715
27	Soil, natural, Washington Rock, Somerset county	1,829	6,219	1,359	715
28	Soil, natural, Mount Horeb, Somerset county	2,613	4,670	662	941
29	Soil, natural, Ten Mile Run Mountain, Middlesex county	3,310	2,090	1,340	400
30	Soil, natural, Rocky Hill, Mercer county	2,258	1,724	2,242	888

TABLE I.—(CONTINUED.)

		Potash, Pounds.	Lime, Pounds.	Phosphoric Acid, Pounds.	Nitrogen, Pounds.
	Marl Soils.				
31	Soil, natural, Holmdel, Monmouth county	8,187	505	3,571	1,202
32	Soil, natural, Edinburgh, Monmouth county	1,324	278	3,240	418
33	Soil, cultivated, Thorofare, Gloucester county	1,655	1,829	1,846	923
34	Soil, cultivated, Thorofare, Gloucester county	2,323	1,916	1,672	1,480
	Silicious Soils.				
	Miocene Soil.				
35	Soil, natural, Shiloh, Cumberland county	3,310	5,400	871	1,983
	Oak-land Soils.				
36	Soil, natural, Bricksburg, Ocean county	732	331	261	435
37	Soil, uncultivated, Chas. H. Irons, White Oak Bottom, Ocean county	662	376	452	680
38	Soil, woodland, White Oak Bottom, Ocean county	1,380	258	1,448	610
39	Soil, Geo. W. Cowperthwaite, Toms River, Ocean co.	638	361	533	663
40	Subsoil, under No. 39	783	243	348	488
41	Soil, natural, east of Whiting's, Ocean county	431	120	431	471
42	Subsoil, Cedar Bridge, Ocean county	951	71	452	....
43	Soil, Egg Harbor City, Atlantic county	627	191	330	279
44	Soil, natural, Weymouth Road, Vineland	958	435	1,341	645
45	Soil, natural, Dr. T. T. Price, Tuckerton, Burlington county	568	207	396	261
46	Soil, natural, Mauricetown, Cumberland county	690	292	534	522
	Pine-land Soils.				
47	Soil, Bricksburg tract, Ocean county	17	29	....	....
48	Soil, Dillon's Island, Toms River, Ocean county	....	....	....	296
49	Soil, Stanton tract, 2 miles south of Toms River, Ocean county	241	....	310	....
50	Subsoil, under No. 49	129	310	482	244
51	Soil, East Plains, Burlington county	609	435	670	....
52	Subsoil, under No. 51	540	209	783	....
	Alluvial Soils.				
53	Soil, Bacon Neck, Greenwich, Cumberland county	2,787	5,400	2,683	3,536
54	Soil, Downes Edmonds, Cape May	3,136	9,232	1,045	2,334

2.—Crops and mineral matters in them which are taken from an acre of soil in a five years' rotation:

Year.	CROP.	WHOLE CROP. Pounds.	Bushels.	ASH OF CROP. Pounds.	POTASH. Pounds.	LIME. Pounds.	PHOSPHORIC ACID. Pounds.
1	Red clover	4,000		268	92	91	27
2	Red clover	4,000		268	92	91	27
3	Indian corn	3,444	61.5	49	14	2	22
	Corn stalks	4,375		240	85	26	20
				289	99	28	42
4	Irish potatoes	17,920	298.6	400	223	8	50
	Irish potato tops	10,080		180	50	31	14
				580	273	39	64
5	Wheat	1,500	25	25	7	1	11
	Wheat straw	3,000		153	18	9	8
				178	25	10	19
	Total five years' rotation			1,583	581	259	179

3.—Crops and mineral substances taken from an acre of soil in another five years' rotation:

Year.	CROP.	WHOLE CROP. Pounds.	Bushels.	ASH OF CROP. Pounds.	POTASH. Pounds.	LIME. Pounds.	PHOSPHORIC ACID. Pounds.
1	Timothy hay	4,000		280	81	26	30
2	Timothy hay	4,000		280	81	26	30
3	Indian corn	3,444	61.5	49	14	2	22
	Corn stalks	4,375		240	85	26	20
				289	99	28	42
4	Oats	2,000	66.6	58	10	2	11
	Oat straw	3,332		170	33	14	4
				228	43	16	15
5	Rye	1,400	25	19	5	1	9
	Rye straw	4,200		168	29	15	6
				187	34	16	15
	Total five years' rotation			1,264	338	112	132

In all good farming, however, more or less live stock is kept to consume the coarser and heavier products of the farm, and the animals are sold, while the manure is returned to the soil to enrich it. Much of that taken out of the soil is restored to it again in this way. In the rotation above given, the clover, the cornstalks, the straw and the potato tops are all kept on the farm, and a part of the wheat, potatoes and corn, and the lime, potash and phosphoric acid in them, are restored to the soil in the manure from the stables and the cattle sheds, so that not one-third of that taken out of the soil by the crops is sent off the farm. Skillful farmers will always manage to make the waste from selling the fertilizing elements of their soil, just as little as they can. If good crops taken from the soil would exhaust it in ten or fifteen years, it can be kept in order three times as long if only one-third is sold off.

To replace the potash taken out from one acre in the five years' rotation, would at the lowest present prices of potash cost $40.67, and to replace the phosphoric acid would cost $17.90—or, per acre, nearly $12 a year. The value of land must then depend to a considerable extent on the amount of these constituents naturally in the soils, this value being modified by the condition of the soil and the ease with which it is managed and tilled.

The principle, however, must everywhere be admitted and acted on that crops take valuable substances from the soil, and these must be restored in some form, or the capability of the land for growing crops will be destroyed. Attention to this principle enables farmers on the lighter lands of southern New Jersey to raise as good crops as are grown in the northern part of the State.

The land needs in addition to barn-yard manure, however, other fertilizers to some extent in order to cultivate them to the best advantage. Of fertilizers, those which can be used to the best advantage in most places are muck and greensand marl. Every bushel of marl contains at least 5 pounds of potash, 1½ pounds of phosphoric acid, and it can be bought for from 4 to 10 cents, according to the distance from the marl pits. Twenty bushels of marl make a ton, and five tons are enough to supply the whole of the potash and phosphoric acid for the five years' rotation—or a ton a year, which may cost from $1 to $2. It is true the potash and phosphoric acid in the marl are both so combined in it that they do not dissolve in water, and so become fertilizing; but

under the influence of the vegetable matter in the soils, or of the farm-yard manures with which they may be composted, they gradually become soluble; and under the influence of muck or of muck and lime, they undergo the same change. There is, then, an abundant supply of potash and phosphoric acid to be had cheaply in greensand marl. Analyses of the marls most used are given in the table following:

TABLE.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Phosphoric Acid........	1.14	1.33	1.02	2.24	2.69	2.56	3.58	3.87	2.58	2.30
Sulphuric Acid.........	0.14	....	.27	.39	.26	.22	.97	.31	1.89	....
Silicic Acid and Sand.	38.70	46.03	50.23	50.80	49.40	51.50	53.15	54.75	59.80	57.67
Carbonic Acid..........	6.13	....	....	....	....	....	....	.. ..	....	....
Potash......................	3.65	5.67	6.32	5.18	6.31	4.62	3.75	4.11	4.25	3.53
Lime.........................	9.07	2.01	1.40	2.13	2.52	1.26	3.27	5.46	2.97	1.26
Magnesia..................	1.50	3.47	3.45	3.54	3 24	3.95	1.75	2.99	2.00	3.67
Alumina..................	10.20	7.86	7.94	8.77	8.90	6.01	8.79	6.46	6.00	10.10
Oxide of Iron............	18.63	25.23	20.14	17.63	17.11	21.04	15.94	15.20	11.98	14.16
Water.....................	10.00	8.40	9.00	9.66	9.10	7.39	8.98	6.85	8.32	7.25
	99.16	100.00	99.77	100.34	99.53	98.55	100 18	100.00	99.79	99.94

No. 1 is an average of the variety of marl most largely used in eastern Monmouth. It is from the Lower Marl Bed, not particularly rich in phosphoric acid, but remarkable for containing from 10 to 20 per cent of carbonate of lime in fine powder.

2. Marl from the Cream Ridge Marl Company, Hornerstown, Monmouth county.

3. Marl from the Pemberton Marl Company's pits, Pemberton, Burlington county.

4. Marl from Kirkwood, Camden county, and from the Middle Marl Bed.

5. Marl from the pits of the West Jersey Marl and Transportation Company, near Barnsboro, Gloucester county.

6. Marl dug at Dickinson's pits, at Woodstown, Salem county.

7. An average of five analyses of Squankum marls from as many different marl banks, near Farmingdale (Squankum) Monmouth county.

8. An average sample taken from a heap of 100 tons sent by the Squankum and Freehold Marl Company to New Brunswick.

9. Marl dug at the pits of the Squankum Marl Company, near Farmingdale.

10. Marl from the pits of the Vincentown Marl Company, near

Vincentown, Burlington county. This comes from the green marl layer of the Upper Bed.

The above analyses are only averages. Single samples from any of them may be found which are much richer, and others which are very much poorer. Complaints are frequently made that the marl is not good. Some of these may be well founded, but others are not. Those selling can supply equal to these analyses, and it is their interest to do so. The difficulty may sometimes arise from injudicious use, or from dry seasons. Marl is not a quick, but it is a lasting fertilizer. Its quickest and best effects are seen upon clover and grass.

Marls more or less calcareous, of the miocene age, are dug near Shiloh, in the western part of Cumberland county. They have been found very beneficial to the soils, and are used generally by farmers for miles around them. Their composition is shown in the following analyses. No. 1 is an average sample from Ayers' pits, and represents the grey, calcareous marl. No. 2 is from Hummell's pits, on the Horse Branch, and is a black marl.

	1.	2.
Silica and quartz	59.30	65.53
Alumina	2.84	5.59
Oxide of iron	3.07	6.08
Lime	15.30	2.71
Magnesia	0.69	2.65
Potash	0.97	1.12
Soda	0.58	
Sulphuric acid	3.56	6.70
Phosphoric acid	0.45	2.00
Carbonic acid	9.00	....
Organic matter	....	2.12
Water	2.80	5.17
Total	98.56	99.67

Muck, or black earth, is abundant in all the swamps and wet grounds of southern New Jersey. It is vegetable matter partially decayed, and while in the swamp is undergoing no further change. It has then no fertilizing value, but when dug out and exposed to sun, air, moisture and to frost, it soon begins to change and decay. Its change can be hastened by the addition of lime, lime and salt, or barn-yard manure. It is then in good condition to apply to the soil. Its office appears to

be to improve the texture of the soil, to increase its power of absorbing moisture from the air, to furnish a solvent for the mineral substances in the soil and in mineral fertilizers, and to become the medium of communication between the soil and the growing crops. It does not contain more potash or phosphoric acid than is found in ordinary soils, and can of itself only help to exhaust them quicker, but mixed with marl or other fertilizers in the soil, it increases the crop very largely.

Analysis of muck from a pine swamp bottom, Toms River, Ocean county:

Organic matter	77.800
Water	7.950
Matters insoluble in acid	13.800
Alumina	0.174
Oxide of iron	0.250
Lime	0.031
Magnesia	0.216
Potash	0.070
Phosphoric acid	0.026
Carbonic acid	0.008
Chlorine	trace
Sulphuric acid	0.034
	100.359
Nitrogen	1.059

The sample was a good average, and was taken from a ditch bank. The bed of which it is a representative, has a depth of about three feet. Such beds are common throughout Ocean, the eastern part of Burlington, Atlantic, Cumberland and Cape May counties. Those of all other parts of the State are nearly the same. This muck, it will be seen, contains 20 pounds of nitrogen to the ton, so that it is capable of adding to the soil a very essential constituent, and one which is entirely wanting in the marl.

With these two fertilizers, both of which require little money, the tillage of the oak-lands can be begun in an economical way. The first crops upon them will be light, but gradually their fertility will develop, and with good management very satisfactory crops can be produced. The soils are rather deficient in lime; the marl may supply this deficiency, or common slaked lime may be applied. And there may be cases in which other fertilizers may be more available. But in all cases the fertilizers should be used so as to favor the growth of

a good crop of clover, and when this is attained, the greatest difficulty in cultitvating these hitherto neglected lands will have been overcome.

Nos. 47–52 are analyses of specimens from the pine lands. They are not farmed.

Nos. 53 and 54 are alluvial soils, and they are remarkably productive. They were cleared at the first settlement of the country, and have been cultivated ever since, without manure.

7. DRAINAGE.

The drainage works, on the Pequest, in the Great Meadows of Warren and Sussex counties, are completed. The channel is large enough and the current sufficiently rapid to carry all waters in a freshet without overflowing. There was an ice dam at the breaking up of the stream last spring, which caused the water to overflow the banks, but as soon as that broke the water fell at once within the banks of the stream. The drainage is a complete success, and is now ready for the remaining step in its improvement, viz., that of cutting the side drains and ditches which are needed to carry off quickly the water which falls on these flat grounds. The benefits of draining these rich lands promise to be as great as the owners of them could desire. It is to be regretted that the expense of improvements of as great public importance as this is, and so much to be desired for sanitary reasons, should all be thrown upon the owners of the wet lands. The whole country surrounding is made more attractive, salubrious, aud valuable, and it should share the expense. The land is benefited all that it costs, but the owners find it burdensome to advance the expense before they have realized any profits from it.

The business of the commissioners is not yet closed, being delayed, and their expenses increased, by tedious and unnecessary litigation.

8. WATER SUPPLY.

The question of water supply continues to attract attention in many parts of our State. The increasing density of population and the consequent accumulation of waste, filth and decaying substances on the surface is liable to, and in many cases does contaminate well-waters so as to render them unfit for use. Then, too, the increasing wealth of our people leads them to seek for the larger supplies and greater comfort to be obtained by having water carried in pipes to all parts of a house, and drawn by the simple process of turning a faucet.

A large number of samples of well-water have been sent to the laboratory this year by anxious housekeepers, to learn whether they were wholesome and safe to use for drinking. We have tested many of these and returned answers to the inquiries, according to the best judgment we could arrive at. This judgment, however, has to be formed as much from the history of the water as from the chemical examination. To determine whether water is hard, we take a gill or thereabouts in a flask and add to it a clear solution of soap in alcohol. If the mixture is then shaken and remains clear with an abundance of soap bubbles over it, the water is soft, but if it becomes white, and curdy-looking masses form and float in it, and no bubbles appear on the surface, it is hard water.

The hardness is caused by salts of lime and magnesia which are in solution in the water. These salts render the water unfit for washing, as they destroy soap, and they are troublesome in tea kettles and in steam boilers, on account of the incrustation which is formed as the water boils away. But hard water is not specially unwholesome, and it is common to find well-waters containing from 10 to 60 or more grains of solid matter to the gallon, which have been used for years without any injurious effect, though sanitarians recommend that water containing more than 17 grains to the gallon be not used.

Waters containing a very little ammonia or albuminoid ammonia

have been said to be poisonous, and if this substance comes from sewage, filth, or decaying organic matter such as accumulates about dwellings, there is danger of its being so, especially in hot weather. But if it comes from partially decaying weeds, grass or other vegetable matter, such as is found in brook or river-water away from settled population, there is no danger to be apprehended from its use—it may be disagreeable but is not dangerous. The test for this substance is very delicate, and to estimate the amount requires much care on the part of the chemist. In brook, river or lake-waters in thick-settled countries this substance is to be regarded with suspicion, and well-waters containing it should not be used. The test, however, is not an easy one, and almost as satisfactory trials can be made by testing for chlorine or for common salt. Pure well-waters as well as common brook-waters contain scarcely a trace of chlorine, while it is always found in sewage water and amongst the organic and waste matters that are thrown on the ground about houses. The well-known test for chlorine, or for salt, is to take a clear solution of lunar caustic or nitrate of silver in pure rain-water, and add a few drops of it to the suspected water, and if it contains chlorine or salt a bluish-white cloud will form in the water. If the test shows chlorine it is safe to reject the water, or at least to boil it before drinking. Boiling water destroys the organic poisons which it contains.

The temperature of water in a well at different seasons of the year, will give indication as to whether the water is of surface origin or from some deeper source. At a depth of about 50 feet below the surface of the ground, the temperature of the earth is unchanged throughout the year, no warmer in summer, no colder in winter. This temperature is the mean, or average, for the year at the place of observation. In New Brunswick it is 52°, in Newark it is 51°, in Vineland 53°, and in some places in northern New Jersey as low as 48°. In deep wells, over 50 feet, the temperature is increased about 1° for every 50 feet in depth, but remains the same throughout the year. Wells supplied from surface water grow colder in winter and warmer in summer which those from deeper sources do not.

The following analyses of waters from Lambertville, Hunterdon county, were made at the suggestion of the Lambertville Water Company. The samples were collected by Dr. G. H. Larison, on the 9th of October of this year, at a time when streams and wells were very low,

and when water is likely to be more impure than at any other season of the year:

Analyses.

		Ammonia in 10,000,000 parts of water. Free.	Ammonia in 10,000,000 parts of water. Albuminoid.	Chlorine, number of grains in a gallon.
1	From Delaware river at the water-works pump on Island creek	10.70	10.55	.355
2	From Alexsauken creek	8.00	11.25	.150
3	From clay pit at brick-yard above reservoir	2.67	19.80	.050
4	From water-works pipe, at dead end	4.00	12.50	.100
5	From water-works pipe, 8-inch main at Dr. Lilly's	16.00	14.00	.200
6	From Union Fire Company's cistern	2.00	8.00	.100
7	From Dr. Lilly's well, at his residence	3 33	7.25	1.400
8	From well in 1st ward, S. Main St	1.33	7.50	2.400
9	From John M. Matterson's well, east side of city	1.00	11.50	5.200
10	From C. W. Kitchin's well, at hotel	1.33	9.92	20.500
11	From new school-house well	8.00	8.25	3.350

	Grains of solid matter in 1 gallon of water. Dried at 212°.	Grains of solid matter in 1 gallon of water. Burned.'	Hardness, in grains of carb. lime in a gallon.
From Delaware river	6.50	3.50	3.90
From Alexsauken creek	8.50	5.75	4.10
From clay pit at brick-yard	7.50	4.25	4.68
From water-works pipe at dead end	6.35	3.80	2.56
From water-works pipe at Dr. Lilly's	6.50	4.00	3.10
From Union Fire Company's cistern	4.82	2.77	2.40
From well at Dr. Lilly's residence	17.15	10.50	6.60
From well in 1st ward, S. Main St	23.10	11.35	5.40
From John M. Matterson's well	42.50	22.50	15.50
From C. W. Kitchin's well, hotel	83.50	56.00	39.52
From well at new school-house	18.00	10.00	5.52

9. ARTESIAN AND DRIVEN WELLS.

At various places in the State a number of deep wells have been bored, with the hope of reaching water which would rise to the surface and flow over, forming true artesian wells. But very few have been successful to that degree; however, a number have been bored in which the water has risen nearly to the surface, and which have yielded a very satisfactory supply. So many such wells have been bored that public attention is strongly and favorably drawn to them.

The well of Messrs. E. Balbach & Son's smelting and refining establishment, in Newark,* is located near the Morris canal, and only a few feet above tide-level. It is 500 feet deep, of which about 100 feet were in sand and gravel, and the rest in red sandstone rock. It is tubed down to the rock, is 8 inches in diameter, and the water rises in it to a little above tide-level. The water is very clear, a little hard, and has a temperature of 55½°. It yields 500 gallons a minute, and when pumped at that rate the water-surface in the well is lowered 6 or 8 feet. The ground around the well is dug away so as to allow the pump to be set within about 2 feet of the surface of the water.

The water is used for all purposes about the establishment, but is specially valued for its low temperature and its usefulness in cooling the heating furnaces.

The well of Messrs. P. Ballantine & Sons is at their brewery, on Freeman street, Newark, and not far from the well just mentioned, though the ground is perhaps 10 feet higher. It is an 8-inch bore, and is tubed through 90 feet of earth and 10 feet into the rock; the remaining 350 feet is without tube, being all in red sandstone. The water rises to within 24 feet of the surface. It has been tried for water, but is not yet in regular use. The quality of the water is good, being clear and cool. With the pump considerably above the surface of the water, it has yielded 200 gallons a minute, and is expected to

* The wells bored in Newark the past season have been put down by the North American Mining Company, H. M. Waddell, agent.

yield more than twice that when the pump is properly set near the surface of the water.

The well of the celluloid works in Newark is 250 feet deep, and yields a satisfactory quantity of water. This water was analyzed by Messrs. Ballantine, and found to contain in a gallon—

Chloride of sodium (common salt)	0.6	grains.
Sulphate of soda (Glauber salts)	11.7	"
Sulphate of lime (gypsum)	85.1	"
Sulphate of magnesia (Epsom salts)	18.7	"
Carbonate of magnesia	6.1	"
Silicic acid	2.0	"
Grains of solid matter	124.2	

Messrs. Lister Brothers have recently bored a deep well at their works on the banks of the Passaic in Newark. It is 8 inches in diameter and 615 feet in depth. It was sunk 110 feet in earth and 505 feet in rock. The surface is but a few feet above tide, and the water rises to within 2 feet of the surface. It is in constant use, and is yielding at the rate of 800,000 gallons a day. The water is clear and cold, its temperature being 55½°. An analysis of the water shows it to contain 152.34 grains of solid matter to the gallon. The mineral matter in it is composed of the following substances:

ANALYSIS.

Sulphate of soda	15.94	grains
Sulphate of magnesia	25.87	"
Sulphate of lime	106.98	"
Carbonate of magnesia	1.55	"
Chloride of sodium (salt)	2.47	"
	152.81	"

A second analysis of the water from this well, after about six weeks' pumping, shows 145 grains of solid matter and 88.1 grains of sulphuric acid in a gallon, instead of 152.8 grains of solid matter and 89.1 grains of sulphuric acid in the first analysis. Sulphate of lime makes a hard scale in steam boilers, and the large amount of it in this water shows it to be unfit for use in steam boilers, or in any apparatus liable to be affected by an accumulation of scale or sediment. Such water is too hard for laundry purposes, and not to be recommended for drinking or household use. In these large manufacturing establishments it is, however, of great value on account of its being always clear and cold, so that it can be used for condensing or cooling hot substances, and for the ordinary washing and rinsing operations where neither heat nor soap is needed.

The amount of sulphate of lime in the water from all these deep-bored wells which are in the red sandstone is too much to make it desirable for steam boilers. The amount appears to be greatest in that from the deepest wells. Messrs. Balbach & Son report that the water from their well is not near so hard now as it was when they first began to pump it some months ago.

At Paterson, at the Passaic Rolling Mill Company's works, a very deep well has been bored. It is on the flat ground near the Erie railway, and south of the railroad station. This is an 8-inch well, and was bored 6 feet in earth, the rest in rock. Water was found in the rock within 20 or 30 feet of the surface, and it stands about 17 feet below the level of the ground. The well has been sunk 1400 feet, most of it in red sandstone. Some layers of red shale have been passed through, and at 1180 feet a layer of fine quicksand was met, which stopped the working of the drill and rose 8 or 10 feet in the bore. No trial to find how much water the well will supply has yet been made. The well is now tubed, and the work of sinking is continued.

The undertaking has been watched with much interest, for it was hoped that the thickness of the red sandstone formation would be ascertained. The proprietors have shown the heartiest interest in the work, hoping that, besides supplying themselves with a flowing well, they could solve a question of much importance to geology.

At *Hackensack* there are several bored wells now in operation. T. T. Crane, Esq., of that place, has courteously contributed the information in relation to them. He says there were put down some 5 to 7 years ago, wells for Wm. De Wolfe, Garret Ackerson, Jacob Hopper, Huyler & Rutan.

The well of Huyler & Rutan is located on their dock, about 75 feet from the water front, and is 105½ feet deep. It went through 10 to 12 feet of meadow mud; then through blue clay and thin seams of red clay to a depth of 104 feet. At the depth of 104 feet red shale 6 inches thick was struck. When the drill passed through this layer it dropped suddenly 6 inches, and then struck a second layer of shale 7 inches thick. After passing through the latter, water commenced to flow, and has flowed ever since, except when the tide in the Hackensack is out (low water) the flow ceases altogether. And when the tide is up it commences again. The river bed is 15 to 20 feet deep.

Mr. R. P. Terhune on the opposite side of the river, and some 650 feet or more from Huyler & Rutan's, has bored down 135 feet without getting a flow of water as yet.

An artesian well is being bored at the *Secaucus Iron Works*, and near the Hackensack river, in Hudson county. I. P. Pardee, Supt., has favored the Survey with the following account of the strata and the water: The surface of the ground is about five feet above tide.

From the surface down to red shale rock	18	feet.
Red shale	to 370	"
Shaly sandstone	to 395	"
Red, shaly sandstone	from 400 to 600	"
Total depth at date [February 7th, 1880]	600	"

The diameter of the bore is 6 inches. When the hole was down 210 feet they commenced to pump with a 4-inch pipe down 60 feet, and with a seed bag at lower end to keep out the surface water; pumped about fifteen gallons per minute of beautifully clear water, but decidedly brackish to taste.

When the bore had reached a depth of 304 feet they pumped with 4-inch pipe, with seed bag attached, and down 100 feet. The result was a large volume of water, but it was still brackish. On evaporation it gave 110.67 grains of solid matter per gallon, which tasted strongly of common salt. When at the depth of 600 feet they pumped with a regular oil-well pump, with the seed bag attached, and having a 4-inch pipe down 250 feet, attached to the end of which was the pump barrel 3⅝ inches in diameter, making a total length of pipe down, 257 feet. The result was only *one* gallon per minute. The 4-inch pipe and the pump barrel were then taken out and put down 200 feet. On pumping, got 20 gallons per minute of very clear water, which, when tested with nitrate of silver, gave a slight percipitate. The water, on evaporating, gave 12.37 grains of solid matter. The difference in the volume of water as 257 feet and 200 feet appears to show that about all the water (not salt), which they have obtained so far, comes in between 200 feet and 250 feet down.

They are now putting down the well 400 feet deeper, which will make a total depth of 1000 feet, when it is done.

By way of comparison, they had other waters there evaporated to dryness and weighed. The drinking-water from the well near the furnace contained 108.76 grains in a gallon; that from the Hackensack river had 307.45 grains to the gallon.

Bored Wells in Jersey City and Vicinity. By L. B. Ward, C. E., of Jersey City.

"Borings of considerable depth in search of water have been made within the past half century in various parts of Hudson county, and in locations differing widely as to topography and geological associations. A geological boundary which passes through Hoboken and Jersey City, and which is in its general bearing parallel with the Hudson river, has been closely touched by the borings made in the tract east of Bergen Hill, these having in every instance entered the underlying rocks. An example of rock-boring for water is also found upon the crown of the Bergen trap ridge.

"In the marshes west of the Hackensack river are a number of wells which have been bored through alluvium and boulder clay. Four of them, which were sunk in 1871, derive their supply from a sheet of water-bearing gravel, at a depth of nearly 200 feet, the water rising to the surface and flowing off in moderate quantity. The water, while it is palatable, has a noticeable taste, said to be of sulphur. The wells now mentioned are upon the line of the Newark plank road; an equal number of wells are to be found on the line of the old Newark turnpike; these are now disused and their origin and depth are unknown.

"Diligent inquiry has failed to find where any rock-borings have been made in that part of Hudson county south of Jersey city. The large works established upon the shores of Kill Von Kull depend for water either upon capacious shallow wells, or upon tubular [driven] wells. The need of suitable supply of water is felt here.

"Upon the smaller islands in the New York harbor, geologically related to Jersey City and Hoboken, no borings for water are known to have been made. On Staten Island a successful well was obtained a number of years since, at the silk mill in New Brighton, by boring to a depth of 400 feet in the underlying serpentine.

"*Notes of the Principal Rock Borings in Hudson County.*

"*Jersey City.*—At Mattheisen & Wiechers' sugar refinery on the south side of the Morris canal in Jersey City, a boring was begun in 1867, which was discontinued in 1872, at a total depth of 1000 feet, inclusive of 20 feet of surface earth, the diameter of which in the upper

180 feet of the rock was eight inches and in the lower 800 feet, four inches. The rocks penetrated were chiefly gneiss and quartz with white sandstone and thin bands of slate, occurring below 800 feet. Several veins of water were met with between 600 and 900 feet, of which the most important were at a depth of 720 feet. The yield was found to be 50 gallons per minute, when tested by pumping. The level in the well being 12 feet below tide, and the temperature of the water 52° Fah. The brackish quality of the water obtained has prevented its use and the well is closed.

"A boring of small diameter was made about 1842 by Mr. Andrew Clerke, in the marsh at the corner of Montgomery and Henderson streets, in Jersey City. Here the red sandstone was met with 15 feet below the surface, and was penetrated to a depth of 200 feet, when a stratum of very hard rock of whitish appearance was encountered, and the work abandoned. A liberal supply of clear, bright water, but strongly impregnated with magnesia and common salt, was found at the depth of 150 feet, which overflowed at the surface. The temperature was not noted.

"In the same marsh, and about 1000 feet northeast of the last, an unsuccessful boring was made a few years later, respecting which details have not been obtained.

"At Cox's brewery, on Grove street, between Seventh and Eighth streets, in Jersey City, the underlying sandstone is covered by about 70 feet of boulder clay and earth. A small boring of 100 feet in depth, was first made nearly thirty years ago, and was enlarged to 5 inches in diameter and carried down to a depth of 400 feet in 1872 and 1873. Small veins of water were met with in the rock at all depths. The water, though so hard as to form a heavy scale in a steam boiler, was of satisfactory quality for brewing purposes. Its temperature was 54° Fah. The well easily afforded 300 barrels of water per day, the water rising in the excavated well to the level of the tide, thence passing away through the earth to the street sewers. The boring intersected a number of seams in the sandstone, which contained fine earthy matter, and limited the capacity of the well to deliver clear water.

"At Limbech & Betz's brewery, on Ninth, between Grove and Henderson streets, in Jersey City, and 800 feet northeast of Cox's brewery, the sandstone is covered by 40 feet of boulder clay, with 30

feet of surface sand. A boring 8 inches in diameter was made here in 1875, penetrating the red sandstone rock 776½ feet to reach water, which was found at the bottom in a stratum of white or light-colored stone. At its completion, the well, when tested by pumping, yielded 33 gallons per minute continuously for 24 hours. The water * is sufficiently soft and sweet for brewing, but is ordinarily used only for cooling purposes, its temperature being 52½° Fah. The well affords 1000 barrels of water per day without difficulty, the level of the well being 10 feet below tide, or 25 feet below the surface of the ground.

"Borings made to rock at the Pavonia ferry, distant, viz., 2300 feet, 2850 feet, and 3300 feet nearly east from the last, came upon serpentine at 63 feet, 120 feet, and 179 feet below tide, respectively."

Hoboken and Union Hill.—In the marsh, and near the south end of Grand street, in Hoboken, a boring was made in 1828, which is mentioned in Mather's "Geology of New York" as 400 feet in depth, reaching rock at 40 feet, and has penetrated serpentine, sandstone, and supposed white marble. This boring probably did not come upon water, and the work was abandoned. Mr. Theodore Van Tassell recollects to have seen the boring apparatus remaining in position some years later.

"At the Palisade brewery, at the summit of the main ridge of Bergen Hill, and corner of Hudson avenue and Weehawken street, in the town of Union, a boring 7 inches in diameter was carried down in 1877 and 1878, through trap, to a depth of 297 feet from the surface, water being found in quantity, increasing with the progress of the work. The well is pumped from the bottom, and yields 250 barrels per day of very pure, soft water, of a temperature of 51° Fah. When not pumped it discharges a much smaller quantity, at a level of 161 feet above tide, into the bottom of an excavated well, 28 feet under ground and 12 feet below the surface of the rock."

At New Brunswick a number of wells were bored 20 or 30 years since; those on grounds not much above tide level were flowing wells,

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**Analysis of Water of Well of Limbech & Betz.*

Soda	39.5	grains in 1	gallon.
Lime	6.95	"	"
Magnesia	9.36	"	"
Sulphuric acid	4.11	"	"
Chlorine	65.50	"	"
	125.42	"	"

while in those on higher ground the water does not rise to the surface. One bored in the old paper mill at Raritan landing, 303 feet deep, and on ground some 12 or 15 feet above tide, delivered 40,000 gallons a day, some 10 feet or more above the surface. It still continues to flow; the bore was not more than 4 inches in diameter. The water was clear and answered for paper-making, though it was very hard. Sulphate of lime was the chief mineral constituent. Two other flowing wells—one at the residence of Richard Johnson, Esq., the other in a field formerly belonging to Dr. H. Pool and near Mile Run—which were bored many years ago, are still to be seen. They were probably not so deep as the later wells, and the quantity of water they supply is not large.

The well bored by the late David Bishop, Esq., at his residence in New Brunswick, is 455 feet deep, all in red shale. It is on a hill 90 feet above tide and the water rises to within 10 feet of the surface. The water is clear but so charged with sulphate of lime as to be unfit for use. The quantity of water to be obtained from the well is inconsiderable.

Some other wells have been bored in the rock about New Brunswick for the supply of private dwellings. They are at depths of from 30 to 60 feet, and for the moderate quantity of water needed in a household have mostly been satisfactory. In some instances, however, they have failed to yield a supply.

Bored wells at Plainfield, Middlesex county.—Mr. Wm. S. Stillman informs me that there are several wells at that place. One "on the premises of Mr. Finch on Park avenue, about half a mile from the depot. It is on the flat or level ground of the city, and has a total depth of 102 feet, of which 60 feet was in earth and 42 feet in rock. The size of the bore is 2¼ inches. The supply of water is ample, and it rises to within 7 feet of the surface. The water is soft.

"Another well is on the premises of J. B. Brown, on Park avenue about three blocks from the depot. It is on the flat ground of the city. It is 107 feet deep, of which 60 feet were in earth and 47 feet in rock. The bore is 1¾ inches. The supply is all that is needed and the water very soft. It rises in the tube to within 14 or 15 feet of the surface. Mr. Brown says he struck the best vein of water at the depth of 65 feet.

At Perth Amboy a well was bored for the Easton and Amboy Rail-

road Company. It was sunk through successive beds of sand and clay of the Cretaceous formation to the depth of 130 feet, but no water was obtained. An account of the strata passed through is given in the Geological Report on Clays, p. 183.

The following clear and interesting account of the well at the terminus of the Easton and Amboy railroad at Perth Amboy, was furnished, at my request, by Alfred Hall, Esq., of that city. In his letter of December 11th, he says: "No supply of water was obtained from the bored well made by the railroad company; that is, from the bored part of it. I watched the progress of the well with much interest as far as it was excavated by digging, which I think was about 30 feet, to where the boring commenced. The well was about 20 feet in diameter, and the earth excavated was composed of a mixture of sand, loam, clay and gravel for a depth of about 17 feet; it was sufficiently compact to stand without support. At this depth water was struck, and a stratum of coarse gravel 3 to 4 feet thick, through which the water flowed abundantly. The gravel was rounded quartz pebbles, like that from Bonhamtown; below this gravel was fine sand, inclining to run like quicksand. At great expense a row of piles was driven close against each other, and tightened up so that they could excavate for a reservoir for the water. They succeeded in deepening the excavation about 7 feet, making the whole depth of the well 30 feet. Inside of the piles a stone wall was built and continued up about 10 feet above the surface of the ground, on top of which was placed a large tank. From the large flow of water through the gravel I supposed there would be a continuous and abundant supply, but in about one year the water gave out entirely. I was told this week, by the man in charge, that there was not one foot of water in the well.

"We use a large quantity of water at our terra-cotta factory—from 400 to 500 barrels daily. Our supply has been taken, principally, from a well sunk but little below low tide. This season we have used more than usual, which, with the long-continued dry weather, made our supply hardly sufficient, and we drove two 1½-inch pipes from the bottom of the well 15 feet down, a large portion of the distance through a very fine quicksand. These pipes were connected with each other, and also connected with a 2-inch suction pipe attached to the pump. At the ordinary speed of our engine, about 1000 barrels of water in a day of 24 hours can be raised. Just below low tide there

appears to be a thick bed of quicksand. Water is found above and below this, but the water below is much purer than that above, being clear as crystal. It is hard water.

"The same experience was had at the metallurgical works, and the same two strata of water found at the same depth relative to tide-water. The water was tested and found to contain some alum and soda, very little iron, and no lime. The engineers say it makes no scale or deposit on the boiler; that the flues are bright and clean, and there is no sign of corrosion or injury to it. There is some difference in the water at different locations; from a pipe driven about 200 feet inland, the quicksand was struck on a higher level, and the water is softer, and a good water to drink, showing that it is affected by a difference in the strata through which it is filtered. This water question I consider an important one. I have long been of the opinion that we have an abundant supply of water for our city right under us."

At the State Reform School, Jamesburg, Middlesex county, a well 8 inches in diameter has been sunk to a depth of 285 feet. The tube was stopped by cemented earth at this depth, but the boring tool has been sunk some 15 or 20 feet further. The boring has passed through the successive layers of the clay formation, and a moderate supply of wholesome chalybeate water has been obtained; but the water being unfit for laundry purposes, on account of the iron in it, the boring is still in progress, in the hope of meeting solid rock, and perhaps soft, clear water.

The experience with water at Jamesburg is interesting. The former supply was from wells, and from springs which came out on the slope 15 or 20 feet below the level of the high ground on which the school is located. The spring water is evidently the drainage from the gravel and sandy loam which forms the top layer of the high ground, and of course the water, though soft and clear, must be polluted by the surface soil drainage, and this probably made still worse by the defective sewerage from the buildings. The school has about 270 boys, and the teachers and other attendants make the whole number of persons there over 300. In August, 1878, there was an outbreak of typhoid fever of a mild form; before it ended, more than seventy boys were attacked, and two died. The use of water from these wells and springs was discontinued, and this, with perhaps other sanitary regulations, soon checked the advance of the disease, and no new cases

occurred. This summer a case or two, like those of last season, occurred, but the use of the chalybeate water from the bored well put an end, at once, to the disease.

The section cut by this well is furnished by Mr. Eastman, superintendent of the school.

Thickness of each stratum. Feet.	Inches.	Description of Material.	Depth from surface. Feet.	Inches.
9	......	Yellow sand	9	......
4	......	Yellow sand and gravel (from 12 to 13 feet, water)	13	......
30	... ..	Black clay, containing very little sand—moist	43	......
8	6	Dark sand, somewhat colored with green, containing a little clay. Rather dry. (From 46 to 47 feet, some whitish clay, rocks, lumps, and thin layers.)	51	6
	6	Sand rock	52	......
12	......	Dark and greenish sand, containing a little clay, and of a marl nature. Rather dry and crumbly	64	......
1	6	Black clay	65	6
4	6	Dark and greenish sand, containing some clay, rock and thin sand crusts. Rather dry	70	......
	6	Sandstone	70	6
5	......	Black clay	75	6
4	6	Black clay, with some sand and a little stone in it	80	......
12	6	Black clay containing very thin layers of white sand	92	6
1	......	Hard, dry, whitish clay	93	6
15	......	Black clay, with thin layers of white sand	108	6
1	6	Stiff, dark sand	110	......
23	6	Fine beach sand, water-bearing, somewhat muddy, and partly of a quicksand nature, containing more or less wood, some floating sandstone, and clay lumps	133	6
1	......	Black clay	134	6
12	6	Fine sand, water-bearing, containing wood, stone and mud, same as above	147	.....
3	6	Black clay, with thin layers of white sand	150	6
13	6	Fine sand, water-bearing, containing some mud, wood and stone	164	......
14	6	Brown clay, very compact and solid, some wood, and its general appearance is of a vegetable nature	178	6
4	6	Brown clay, containing considerable sand and more wood. Rather dry. (At 173 feet 9 inches, and at 178 feet 6 inches, lumps of iron pyrites.)	183	......
8	6	Fine sand, water-bearing, containing some mud, wood and floating sandstone	191	6
	6	Dark clay	192	
10	9	Coarser sand—a more free water stratum—a few floating clay lumps, iron pyrites, wood and blue clay	202	9
	3	Bluish clay (on top of it a thin sandstone crust and wood)	203	......
1		Sharp sand; water	204	......

THICKNESS OF EACH STRATUM. Feet.	Inches.	DESCRIPTION OF MATERIAL.	DEPTH FROM SURFACE. Feet.	Inches.
	9	Fine, bluish clay	204	9
12	3	Sharp, clean sand, water-bearing	217	......
	3	Wood, worm-eaten	217	3
1	......	Coarse sand and fine gravel, well mixed, and with lumps of white clay	217	3
5	9	Sharp sand, with lumps of bluish clay. (At 223 feet 6 inches, crusts of iron pyrites.)	224	......
7	......	Fine beach sand	231	......
2	3	Sharp sand, coarser	233	3
	3	Whitish clay	233	6
2	6	Sharp sand, with scattering whitish clay lumps	236	......
1	......	Coarse sand and fine gravel, well mixed with white clay lumps	237	......
1	......	Fine, lively sand	238	......
1	9	Coarse sand and fine gravel, well mixed with white clay lumps	239	9
	3	Whitish clay	240	......
	9	Sharp sand	240	9
	3	Whitish clay layer	241	......
10	......	Fine beach sand	251	......
5	......	Coarse sand	256	......
		(The above 15 feet of sand clean and free from other substances.)		
2	6	Auger below pipe, and struck a sandstone crust	....	......

At Columbus, Burlington county, on the Rancocas stock farm of P Lorillard, Esq., a deep well has been bored. The following account of it has been furnished for this report by Mr. Willard Blasdell, of Philadelphia, who bored this and the Jamesburg wells:

Thickness of each stratum. Feet.	Inches.	Description of Material.	Depths from surface. Feet.	Inches.
14	......	Yellowish loam and sands..........	14	......
34	6	Fine sand, somewhat mixed and colored with dark mud, water bearing..........	48	6
23	6	Stiff, black, sandy clay..........	72	......
1	......	Fine sand, muddy and water-bearing..........	73	......
9	......	Stiff, black, sandy clay..........	82	......
34	......	Fine sand, water-bearing, containing scattering layers of sandstone on clay or shell rock, from 3 to 5 inches thick, some of it quite porous and well bored with worms..........	116	......
1	......	Black, sandy clay..........	117	......
7	......	Fine sand, water-bearing..........	124	......
1	......	Black, sandy clay..........	125	......
3	6	Fine sand, water-bearing..........	128	6
49	6	Dark, sandy clay, containing scattering layers of sandstone and shell rock, 3 to 5 inches thick..........	178	......
128	......	Dark, sandy clay, changeable to more sandy, with scattering layers of sandstone, shell rock, shells and wood..........	306	......
8	......	Fine sand, some gravel, sand crusts and floating brown clay lumps; water..........	314	......
24	......	Red and white variegated clay..........	338	......
18	5	Sand and sand rock alternately, from five inches to two feet thick, with some thin clay veins and considerable wood...	356	5

Shoved the pipe 338 feet 5 inches; bored with auger 18 feet below the pipe; a fair supply of good water was obtained between the sand-rock layers, which rose to within 45 feet of the surface of the ground. At 302 feet a perfect fish tooth was found.

Mr. D. E. Howatt, farm manager at the stock farm, writes that the water is tinctured with sulphur [sulphate of iron] to some extent. "The well is not running now, because the purpose for which it was bored is not yet completed. We tried it, however, with a very large 4-man pump, and could not reduce the height of water at all. From our 156-foot artesian well the flow is about 10 gallons per minute. This water is raised about 30 feet and is slightly tinctured with sulphur [sulphate of iron,] but is beautifully clear, very healthy (slightly laxative when first drank) and decidedly a great success. * * * There is a spring at Brown's Mills, about 6 miles from here, which is called fine for invalids, and to which they come from far and wide. Our water from the 156-foot well is very much like the Brown's Mill

water in taste, a little stronger if anything, and exactly like it to all outward appearance."

A well at the residence of Chas. S. Taylor, Esq., near Burlington, was sunk 200 feet, most of the distance in the dark clays of the lower part of the marl formation and the upper part of the clays. It ended in light-colored clay, but no good supply of water was met. The tube was 8 inches in diameter.

At the residence of Dr. Van Buren, at Shrewsbury, Monmouth county, a well was bored through several strata of the marl formation to the depth of 200 feet, but water was not found.

In the Great Swamp, Passaic township, Morris county, Dr. Van Wagenen, had a 2½-inch tube sunk at his farm-house near Myersville, to the depth of 64 feet. It is in clay with very little sand, and enters the red sandstone rock 8 feet. It is a flowing well, and yields a sufficient supply of water for his farm stock.

Hon. F. S. Lathrop, on his farm in the Great Swamp, near Madison, has sunk a 2½-inch pipe through strata of sand, clay sand, and fine sediment, to the depth of 165 feet. No water has been found and the rock has not yet been reached. The material appears to be too close for water to filter through it. The basin in which it is located is surrounded by a rocky rim, which in its lowest part is not 10 feet below the surface at the well, and there is no outlet for water below that level. If the material were sufficiently open for water to run through, it should rise in the tube up to very near the surface.

An artesian well was bored at Winslow for Hon. A. K. Hay, about twenty-five years ago, for water supply for steam engine at the Winslow Glass Works. The elevation of the surface is about 115 feet above mean tide. The well was bored 335 feet, 220 feet below the level of the sea. The following strata were passed through:

Surface earth	5	feet
Blue and black clay	15	"
Glass-sand, described as quicksand	95	"
Miocene clay, described as hard, black clay	35	"
Micaceous sand, described as quicksand	107	"
Brown clay, described as black, hard clay	43	"
A gum log, one foot in diameter, found here.		
Greensand marl and white shells, teeth, &c.	20	"
Pure greensand—no fossils	15	"
	335	

Water rose from the bottom of the greensand.

The geological relations of these beds are described on pp. 291 and 292 of the "Geology of New Jersey."

The analysis of the water of this well, as made for the report in 1868, is here given.

1000 parts of water gave:

Silica	.0140
Chlorine	.0002
Sulphuric acid	.0027
Carbonic acid	.0520
Peroxide of iron	.0030
Lime	.0202
Magnesia	.0079
Potash	.0100
Soda	.0554
Solid matter in 1000 parts of water	.1654

This well-water has much excess of carbonic acid, keeping in solution the alkaline earths as bicarbonates.

The well was bored 343 feet deep to get a supply of water which would not corrode a steam boiler. The experiment was entirely successful. Sufficient water was obtained, and the boiler has not corroded since.

The sediment deposited is a soft and sandy one, and without any tendency to incrust, and the water in the boiler finally becomes very strongly alkaline from the abundance of carbonates of potash and soda accumulated in it.

Well at Harrisville, Burlington county.—This was a well intended to supply pure water for the paper mill there. Mr. R. C. Harris says: "In 1866 I had an artesian well sunk at Harrisville, to obtain a supply of pure water, free from iron, from which ingredient we had a great deal of trouble, causing our wrought-iron boiler to rust out rapidly. The well was sunk to the depth of 306 feet, and lined with 6-inch tubing. Gravel, blue and gray clay were passed through, until a depth of 180 feet was reached; mud, sand, and what appeared to be decayed wood, were also encountered. Further on, a gravelly bed was found, and water suddenly spouted up, reaching the top of the tubing, 8 feet above the ground. Water continued to flow quite freely, and it seemed to be pure and free from iron. The party doing the work, thinking to do better, persuaded me to let him go on; and, after a great deal of labor, he reached the above depth of 306 feet. The result was, no water of any volume; and that which overflowed was impregnated with iron very strongly, which was the very thing I

wished to avoid. At this I concluded to abandon the project, and declined to bore any further."

The occupation of the sand beaches on the Atlantic coast, from Sandy Hook to Cape May, as sites for summer hotels and résidences, and the rapid increase in the population at Sea Bright, Ocean Grove, Ocean Beach, Beach Haven, Atlantic City, Cape May City, and other points on this coast line, brings up the question of water supplies; and several inquiries have been received, both as to quality and available sources of supply.

Jas. A. Bradley, at Asbury Park, writes: "The greater part of the water used here is obtained by driven wells. They are from 20 to 40 feet deep, and give a bountiful supply of water, and, in almost every instance, the water is most excellent. There are a few open wells, but the driven ones have the preference. No attempt has as yet been made to experiment with artesian wells, but the matter is talked of. Wells have been driven 76 feet, and still in marl substances. In some instances water is not good, on account of marl deposit."

The following paragraphs concerning water supply on the beaches, were written for the report of 1875. It is reprinted, as it is still applicable to nearly all points on them:

Water sufficiently fresh for drinking is obtained on all the sand beaches along the sea shore of New Jersey, by digging holes two or three feet deep in the hollows between the hillocks.

Wells, as they call them, are made by sinking a barrel or hogshead, from which the heads have been taken out, into the sand to the depth of from two to six feet, and removing the sand from the inside of the cask. The water rises in the inside of the cask to within a foot or two of the top, and the well is complete. It needs no bucket or pump, and is usually without cover or curb, so that the water can be dipped out with a pail. Wells of this kind, situated so that water from the sloughs or from the sea could not readily soak into them, were considered to be good enough, when but few people lived on the beaches, but as population increases, and waste matter, refuse and filth, of every sort, accumulate upon the surface, the products of their decay will naturally be carried into the sand with the rain, and so find their way into the wells. The necessary consequence of drinking water poisoned in this way is soon seen in the increased sickness and mortality among those who use it, especially in summer and autumn. The first and easiest means of

supplying *pure* water, is to collect rain, from roofs, into cisterns, and it has been resorted to with most satisfactory results. The large hotels, and the better class of houses, are being provided with cisterns, and are able to store water enough for all purposes of domestic consumption; and wherever such water is used there is an entire exemption from the diseases which afflict those who use water contaminated with putrefying organic matter. Cisterns, however, are not provided for the poorer class of dwellings, or for fires or steam.

The question of water supply has been largely discussed at Atlantic City, and various projects have been entertained. An account of the artesian wells, and the quality of the water, is reprinted from the report of 1875:

As early as 1858 the late Manasseh McClees sunk a well 185 feet deep, at Cottage Retreat, near the light-house, and between Atlantic and Pacific avenues. The ground was about six feet above the high-water mark. The materials passed through were:

Beach sand	50 feet.
Blue clay, like marsh mud	5 "
Beach sand	30 "
Very tough blue clay and salt water	5 "
Sand, more or less coarse; water, salt	90 "
Clay, yellow and blue, in streaks; water, salt	5 "
Beach sand and salt water	

The boring was lined with an iron tube eight and a half inches in diameter. The whole cost of this well was $1000. In 1874 the Atlantic City Gas and Water Company sunk two artesian wells on middle of the beach, at the south end of the city, and in ground eight feet above high water. One of these, ninety feet deep, passed through:

Beach sand	60 feet.
Mud and sand	15 "
Beach gravel, and fresh water	15 "

The materials passed through in the second well were:

Beach sand	56 feet.
Beach mud and sand	5 "
Beach sand, gravel and fresh water	57 "
Total depth	118 "

These wells were tubed with 12-inch pipe, and the water rose in them to within 10 feet of the surface. A steam pump was applied and water drawn steadily for 24 hours without lowering it more than three feet in the tube. A gallon of the artesian well-water left, on

evaporation, 24.20 grains of solid matter. This was mostly in the form of mineral carbonates. No nitrates or ammonia were found in it. The water was clear and without smell when examined, though persons present when the pumping was going on, say that it then had a disagreeable smell, which was perceptible at a distance of 60 feet. Water from the well of J. Adams, which is one of the best surface wells in the city, on being analyzed, was found to contain 15.74 grains of solid matter in a gallon. It contained less of carbonates and more of sulphates, and a trace of nitric acid. The water was slightly yellow, and the solid matter when burned, gave off a strong but not unpleasant odor.

The rain-water was, of course, unexceptionable.

The water from the surface wells there is contaminated with organic matter, and it is unsafe to use it. That from the artesian wells is palatable and contains no poisonous organic matter. I think there would be risk in depending upon it for a full supply; for it is apparent from the three borings that the material of the beach is the same from the surface to the bottom of the tubes, and if the wells are drawn hard the water from the sea is likely to be drawn in and spoil them, as it evidently did in the McClees well.

The safe and economical plan is to provide rain-water for domestic purposes, and to construct large surface wells for supplying water for fires, and other purposes not requiring pure water.

An abundant supply of pure and excellent water can be had from Absecon creek, which is a considerable stream on the mainland opposite Atlantic City. The expense of bringing this water across the marsh would be heavy, and may delay the execution of the work, though it will finally be done.

Bored Wells at Cape May City.—R. B. Swain, C. E., of Cape May City, furnishes the following account of the "Water Supply and Artesian Wells" there. He says: "Our supply is from wells of three kinds, viz., surface wells, tube or driven wells, and artesian wells. Before our town became closely built up we had an ample supply from what were quite uniformly good surface wells of depths varying from 5 to 12 feet. As building increased it was found that surface wells became contaminated with the contents of sinks and cesspools, when recourse was had to artesian and driven wells as the means of reaching the two lower strata of water.

"There have been seven 8-inch artesian wells made, at depths varying from 87 to 92 feet, according to the elevation of the land at the point where the well may be made, within a period of about 24 years; developing a stratum bearing fine fresh water, yielding about 75 gallons per minute. Two of said wells, however, were spoiled by the ignorance, carelessness or cupidity of the party who had the contract for making them, by driving them too far, or below the water-bearing stratum.

"The drive wells are 1¼-inch tubes driven from 25 to 30 feet, as may be required from the variable surface of the ground. They will yield from 7 to 10 gallons per minute.

"Water, in all deep wells, will rise to the point at which water will stand in an open or surface well.

"If a tube is driven to either the 2d or 3d stratum and opened, in a surface well, at any point below the point at which water will naturally stand, the water will continuously flow into the surface well, with a force in proportion to the distance at which the opening in the tube may be made below the surface of the water in the open well.

"This town is supplied from one artesian well of 8-inch diameter, settled 84 feet to contact with a cedar log 3 feet in diameter. The 8-inch pipe coming in direct contact with the log, it was necessary to drill inside of the pipe, which curtailed the hole through the log to 6 inches, making the well 87 feet deep. Also from one surface well 20 feet diameter and 19 $^{4}/_{12}$ feet deep, with three sub-wells in the bottom of it, each 3 feet diameter and 6 feet deep. From which sources of supply are distributed, during the summer, about 120,000 gallons daily.

"That you may more thoroughly understand the geological formation, I send you, per express, my specimens, or what is left of them taken from the *first* well made at the Columbia House (excepting the two bottles marked 2d well.) Also a specimen from the drilling of the log under the well at the city water works. Use whatever portion of specimens may suit you. You will find specimens from the surface to 224 feet depth. The exploration to this depth is due to the man employed to sink the well. I had the work suspended at the proper point, and a better well I never saw; but in my absence he drove it through the stratum, expecting to meet other strata; and, as

it could not be remedied, the owner of the property concluded to make an experiment of it to the depth indicated, where he struck salt water."

At the State Prison, in Trenton, a large well was dug last year, 12 feet 8 inches in diameter, and 52 feet deep, down to the solid gneiss rock. Water was first met with in the gravel, 21 feet down, in large quantity, but somewhat hard. The quantity did not increase much until the rock was reached, and then the water was quite soft. The water from the gravel contained about 50 grains of solid matter to the gallon, most of which was sulphate of lime and magnesia, and only a trace of chlorine, and no organic matter. The water from the rock contained less than two grains of solid matter, mostly carbonate of lime, to the gallon, and a very little carbonate of iron.

Several holes of 2 and 3 inches in diameter, and from 4 to 7 feet deep, were bored in the rock at the bottom of the well, and much of the rock water comes from these holes.

The temperature of the water from the gravel on the 4th of October was 59° Fahrenheit, and that of the water taken directly from the rock was 56° Fahrenheit.

To ascertain the quantity of water the well would supply, all the water was pumped out, and then the time of filling up of each foot was recorded.

1st was filled at beginning.		16th was filled in	22 minutes.
2d was filled in	9 minutes.	17th " " "	23 "
3d " " "	11 "	18th " " "	28 "
4th " " "	15 "	19th " " "	29 "
5th " " "	17 "	20th " " "	32 "
6th " " "	18 "	21st " " "	35 "
7th " " "	18 "	22d " " "	43 "
8th " " "	17 "	23d " " "	48 "
9th " " "	20 "	24th " " "	58 "
10th " " "	20 "	25th " " "	76 "
11th " " "	20 "	26th " " "	101 "
12th " " "	20 "	27th " " "	162 "
13th " " "	20 "	28th " " "	251 "
14th " " "	20 "	28¾ stopped rising.	
15th " " "	21 "		

One foot in depth of water in the well is 943 gallons. Now if we take the time of filling this to be 20 minutes, which is the time required when about half the water is out, the well will supply 68,000 gallons in 24 hours, or if it is pumped down till the water is only 2½ feet deep, and kept at that, it will supply 135,000 gallons a day.

It is probable that the amount from the gravel is all a well of this size can furnish; but it may be that a much larger quantity can be got from the rock by sinking the well deeper into it. The rock is gneiss, stratified, not very solid, nor uniform in quality, but open and with the strata almost perpendicular, so that a deepening of the well, in rock which would need no lining, would expose a much greater surface of rock and length of seams from which water could escape.

It is of some importance to notice that while the water in the red sandstone rocks is very hard, and that in the clay district is liable to be impregnated with iron, the water in the gneiss rock is pure and soft. A new well was sunk near Calvary Cemetery, in Brooklyn, this fall. It is about 80 feet above tide, was sunk 60 feet in boulder earth, 160 feet in clay and sand, and 386 feet in gneiss rock. The water is very soft, and with only a very little lime, magnesia, and chlorine in it. It yields about 70 gallons a minute.

The following account of four wells bored for Geo. G. Green, in and near Woodbury, has been furnished by I. C. Voorhies, of that city:

"No. 1. G. G. Green, who owns the steam flouring mill, and also a large sash, blind and planing-mill adjoining, has an artesian well 80 feet deep, cased in with wooden casing 12 inches in diameter. It is situated about 300 feet from Woodbury creek, on Main street. It supplies plenty of water for two stationary engines. The water is soft and good. The first 10 feet was yellow clay; next, 65 feet of green or bluish-colored clay, *oily*, and very tough. No water can penetrate it. The balance was gravel.

"Well No. 2 is bored at G. G. Green's handsome residence in this place. It is 163 feet deep; cased with 4½-inch iron pipe. The first 14 feet was yellow clay and sand; then came 90 feet of blue and greenish-colored clay, or marl; after that there were 59 feet of sand, or fine white gravel. The coarse sand, or gravel, has no clay or loam in it, and looks like sea-shore sand, but coarser; occasionally, a little lot of small pebbles, size of peas to ordinary marbles. Plenty of water was found after getting through the marl; also water in all distances through the sand, but it seems only to be saturation. There are no runs of water, and the supply can be exhausted by two days' pumping.

"Well No. 3 is situated about 600 feet from No. 2, and has wind-power attached to it, and belongs to the same property. It is 132

feet deep, cased with $4\frac{1}{2}$-inch galvanized-iron pipe. The first 14 feet was yellow clay; then came 75 feet of blue or greenish-colored clay, or marl; balance sand, or fine white gravel. At bottom, struck a stratum of fine white clay, very hard, with iron crust at bottom of clay, and had to drill through this, when they struck the same kind of sand again. This will supply about 3000 gallons of water per day. Have some trouble with sand coming up the pipe.

"No. 4 well is situated about two miles south of Woodbury, on the farm of Mr. Green. The first 15 feet was clay; 105 feet of marl. They have never pumped this well, on account of the pump being out of order."

Mr. I. C. Voorhies, of Woodbury, furnished the following statement of wells bored by Caleb Risley, of Woodbury. They are located: two in Woodbury; one a mile north of Woodbury; one at Mount Ephraim, in Camden county; and one at West Creek, Cape May county:

"Messrs. Allen & Madane had a well bored, some four years ago, for the purpose of supplying their engine with water. They found a supply for all their purposes, at the depth of 113 feet. The first 10 feet was sand and clay; then 40 feet of blue mud, or marl; 50 feet of bar sand; the balance was sand and gravel mixed. The last foot had to be drilled. Mr. Caleb Risley, who bored this well, informs me that, after they got down 50 feet, they found plenty of sea-shells in the next 50 feet. It has $2\frac{1}{2}$-inch pipe. Water comes to within 19 feet of the top.

"Lewis M. Green has had a well bored at his new and handsome residence, situated on Main street. This well has been used very extensively. It has furnished all the water necessary for building purposes, and it will be used in the new house when done. There is some talk of attaching an engine to it. It is 142 feet deep. The first 12 feet was yellow clay; then 108 feet of blue marl, mixed with green; 14 feet of sand and gravel; 4 feet of loose sand, and the balance, 4 feet, was hard clay and sand, mixed with shells—very hard, and had to be drilled. In this well, at the depth of 130 to 135 feet, they bored through two logs. It will furnish 500 gallons of water per hour. The supply is supposed to be inexhaustible, and water is within 50 feet of the top.

"Mrs. Deborah Cooper, who lives about one mile north of Wood-

bury, on the Red Bank road, about one year ago had a well bored, which, I am informed, gives entire satisfaction. It is 68 feet deep, The first 10 feet was sand and clay; 50 feet of blue mud, or marl; 8 feet of gravel and sand. The well furnishes plenty of water for use of home and stock on the farm. It has been pumped to 500 gallons per hour, and is supposed to be inexhaustible. Water comes to within 10 feet of the ground. It has a 4-inch pipe in it.

"There has just been a well bored near Mount Ephraim for Joseph Warrington. It is in Camden county. They are now down 130 feet. The first 10 feet was clay; then 100 feet of marl, or blue mud; 20 feet of clay, gravel and sand mixed. In this well were found sharks' teeth, at the depth of 116 to 129 feet, and magnolia roots were found at the depth of 130 feet.

"There is another well, three-quarters of a mile from the above, that is 80 feet deep, and furnishes plenty of good water for farm purposes.

"Messrs. Kirby & Smith, of Woodbury, have a well bored at West Creek, in Cape May county, to supply their engine and works there. This well is situated within 300 feet of Delaware bay shore, on the marsh. The first 18 feet was salt mud; 3 feet of blue clay; 3 feet of yellow clay; 3 feet of pink clay; 45 feet of quicksand; 14 feet of coarse gravel; 27 feet was sand and clay in layers of about 6 feet apart. Water is good and inexhaustible. This well flows nearly to the top, and, with a little ditching, could be made a flowing well. The pipe is 3-inch."

Some interesting trials with driven wells have been made in Newark and vicinity during the past year.

At the works of the Newark Aqueduct Company, in Belleville, trials as to the supply which can be obtained from such wells are now in progress. At our request, J. B. Ward, Esq., Secretary of the company, has furnished the following account of them:

"There are 20 wells, 3 inches in diameter and 28 feet apart. The wells were driven in a straight line across the valley towards the west. The first four wells were driven to a depth of 48 feet below the top of the coping of the filtering basins; the rest were driven to a depth of 42 feet.

"At the top of each well is a right-angled bend, then a pipe, 3 feet in length, connecting the well with the large pipe to which the pump

is attached. This large pipe is 24 inches in diameter at the pump, and gradually decreases to 6 inches in diameter at the end of the line of wells.

"The pumping began on the 8th of September, when the water-surface in the ground was 6 feet 8 inches below the top of the coping. The water in the river is 5 feet 3¾ inches at high tide, and 9 feet ¾ of an inch at low tide.

"The water-surface along the line of wells sank in the centre of the line to a depth of 13 feet 6 inches on the 9th of October; quantity of water pumped per day, 2,750,000 gallons. The water then rose in the ground, and on the 13th it stood 12 feet 11 inches; quantity pumped per day, 2,580,000 gallons.

"The quantity of water pumped has varied from 2,300,000 to 2,800,000 gallons per day. The pump was stopped from the third to the eleventh of November, when the water rose to 8 feet below the coping. Enclosed is a diagram showing the position of the test wells, and also a table showing the daily variation of water in these wells.

TABLE.

	TIME.	HIGH TIDE.	LOW TIDE.
River	5 P. M.	5′ 2½″	....
	1 P. M.	....	8′ 8½″
Well No. 1	8 A. M.	13′ 3¼″	....
	2 P. M.	....	13′ 7″
Well No. 2	8 A. M.	13′	....
	4 P. M.	....	13′ 2¾″
Well No. 3	8 A. M.	10′ 1½″	....
	2 P. M.	....	10′ 5¼″
Well No. 4	7 A. M.	8′ 11¾″	....
	1 P. M.	....	9′ 9¾″
Well No. 5	8 A. M.	9′ 9½″	....
	3 P. M.	....	9′ 11¼″

WM. A. THOMPSON,
Engineer in charge."

From these results it appears that the water in the wells rises and falls with the tide.

The observations show that when the pumping began, the surface of the water in the wells was nearly a foot above mean tide in the river, and that when the pump was stopped, after working a month, the level of the water in the wells was nearly 4 feet below low water mark. The pumping was resumed after stopping a few days,

and has been continued ever since, without very much further lowering of the water surface in the wells. The water must filter through from the river. The pump takes all that the wells now driven will yield. It will be interesting to see if the number of wells can be increased, and water caused to filter through from the river fast enough to supply all that is needed. There is a great deal of interest expressed in regard to these trials; the quantity of water supplied being large, the quality of it satisfactory, and the cost of it not too great.

Twenty-five driven wells were put down near the Newark bay shore, and at the end of Waverly avenue, Jersey City, in 1877, by Matthieson & Wiechers, to obtain a supply of water for their sugar refinery. The ground is 10 to 20 feet above tide level. The strata encountered in them were, in general, the following:

1. Yellow dune sand	1½– 8	feet.
2. Sand and gravel (water bearing)	4– 6	"
3. Bluish sandy clay	1	"
4. Sand and gravel, becoming quicksand at the bottom	15–16	"
5. Reddish, sandy clay, including some gravel, and very sandy at the bottom	15–18	"
6. Trap-rock at bottom.		

The wells were 3-inch bore, and were all connected with one main. When first put down, 324,000 gallons of water were pumped from them daily. The quantity was insufficient, and the quality of the water soon deteriorated, and the wells were abandoned.

North of these wells, and near Marion, several wells were driven. They went through 55 to 68 feet of earthy beds, and to the trap-rock.

At Gautier's steel works in Lafayette, Jersey City, and near the foot of the Bergen hill, the trap-rock was struck at a depth of 90 feet beneath the surface.

Another well, in Jersey avenue and near the Morris canal, and also near the hill, went through 40 feet of mud, then a beach sand 15 feet, and then quicksand 43 feet, and at bottom, lying on the trap-rock, a red sand and clay, 2 feet—in all, 100 feet.

The water in these wells in Jersey City was salt and hard.

10. LABORATORY AND OTHER MISCELLANEOUS WORK.

The work in the laboratory has been kept going constantly. The largest amount of work done has been in the analysis of soils, but besides these, there have been many iron ores analyzed, and some specimens of black lead; numerous samples of water have been tested; some marls, peats and limestones have also been analyzed. The results are given in this report.

So numerous have been the applications for information in regard to ores, mining properties, fertilizers, soils, &c., that we have been obliged to decline analyzing specimens sent by parties who did not own the land from which they were sent; also such as were sent without labels describing the locality, owner of property, &c. There is frequent disappointment expressed that we do not report favorably on specimens brought to us, but there can be no doubt that such advice given saves many men from engaging in enterprises which must have ended in ruinous losses. Information given in this way has in some instances been acknowledged as saving from very heavy expenses.

IRON ORES.

A small number of iron ores have been sent to the laboratory for examination. The recent revival in the ore-mining district, among the old mines and in the business of searching for new ore localities, is noticeable in the increasing number of ores which are now received. The very general demand for ores for making ordinary iron, does not put so much stress upon the presence of phosphorus as upon the percentage of metallic iron. The recent improvement in the methods of roasting ores and the elimination of phosphorus by the new Thomas-Gilchrist process, as also the washing of phosphoric irons for the open hearth and puddling processes, indicate the practicability of working many of our ores which have, until lately, been regarded as worthless. The presence of titanium remains to trouble the iron-

master, although careful examinations show that this element is rarely absent. And future analyses must determine it. Heretofore its determination has been frequently omitted. The analyses of ores which have been made will be found under their respective localities, as described on pages 41–93.

The determination of the titanium has not been generally made until this year. If suspected, it was looked for; otherwise, the examination was omitted. The very general presence of this element in our clays and in some of our gneissic rocks has led to the belief that it is rarely absent from our iron ores. And nearly all of our later analyses indicate its presence. It will be interesting to pursue the inquiry how largely it enters into the composition of some of our best ores. It is not believed that it is particularly injurious when present in a small percentage. It is well known that it makes ores more difficult to work, requiring more fuel and consequently rendering their reduction more expensive.*.

NICKEL, COBALT, &C.

The laboratory receives from time to time specimens of pyrite, said to contain gold, silver, nickel, cobalt, &c. Many such specimens have been examined in previous years, and some of them have been mentioned in the reports. Thus far none of them have been found to contain any metals in workable quantity.

1. *Pyrite from lands of Wm. Witty, at Brasscastle, Warren County. Sent to the laboratory by C. F. Staats, of Washington.*—It was examined, and found to contain 0.4 per cent. of nickel and traces of cobalt.

2. *Pyrite from Califon, Hunterdon County. Sent by Theodore Lance, of High Bridge.*—Nickel in it was 0.3 per cent.

* In Norway the ores of Krageröe and Eger, containing 15.00 and 7.10 per cent., respectively, are worked. If ores do not contain more than 8 per cent. of titanium, their reduction is not difficult and the product is of good quality. They are best worked with non-titaniferous ores, and fluxed with quartz and limestone. An examination of the analyses in this report shows titanium present, from traces to nearly five per cent. These all are used successfully, and are said to make good iron.

BLACK-LEAD, PLUMBAGO, GRAPHITE.

This mineral is found disseminated in the Azoic rocks in many places in New Jersey. It finds a large and increasing use, in making crucibles, in stove-polish, and in lubricating machinery, and this has led to an increased inquiry for cheaper and more abundant supplies of it. Heretofore the chief part of that used has come from Ceylon, though a considerable quantity has been sent into market from Ticonderoga, N. Y., from Stouerbridge, Mass., and from Pennsylvania. Extensive mines have been found and worked to some extent near Ottawa, Canada.

The mineral occurs sometimes in veins, when large masses of it are obtained almost free from rock. The Ceylon mineral, that from Ticonderoga, and part of that from Canada are of this kind. The most common form of its occurrence, however, is in flakes, scales and grains, disseminated through the rock, of which it may form a very small part. The latter is the only form in which it has been found in this State. In the "Geology of New Jersey," it was mentioned as being found in the following places: In a vertical vein or bed of 4 or 5 feet thick in gneiss rock, on land of Elias Englemann, a mile and a half northeast of Peapack, Somerset county. Some of it had been mined out, but not successfully separated from the rock. On the farm of H. C. Saunders, a mile east of Mendham, Morris county. This vein has not been opened, but could be traced upon the surface for several hundred feet. Several shafts were sunk in searching for a vein of this mineral, on the farm of Mr. Betts, west of Morristown, where it appeared in the earth on the surface. There was not enough found, however, to warrant further work. At Bloomingdale, Passaic county, a bed of rock richly charged with this mineral was found, and extensive works were built to separate it and prepare it for market. The enterprise was soon abandoned. In the long cut on the Central Railroad of New Jersey, southeast of High Bridge, in Hunterdon county, some of the rock shows a large percentage of black lead, but it has not been worked.

The localities have been examined during the last year, and samples have been selected and analyzed, as follows:

1. *Bloomingdale.*—This mine was lately visited, and specimens were obtained for analysis. The property is now owned by Samuel Wild's

sons, of New York city. No work has been done in 12 or 15 years. The mine is about a mile south of the village, in Morris county. There are three openings on a northeast and southwest line, on the strike of the gneiss rock. The main one is said to be about 60 feet deep. It is now full of water. The rock, which crops out on the surface on both the northwest and the southeast of the opening, is a micaceous gneiss. From an examination of the material thrown out of this opening and lying about it, the graphite appears as a constituent mineral of the gneiss and of the coarse crystalline rock which is associated with it. The next opening towards the northeast is 80 yards distant. It is a shallow cut across the strata. The gneiss there dips 50° south 80° east. The northeast opening is about 50 yards from the latter, and is 18 to 20 feet deep. The rock dips 70° towards the south-southeast. It is here also a micaceous gneiss, which is traversed by a coarse crystalline, feldspathic rock, and the graphite is found in them both. A brown mica, in large plates, and pyrite occur in scattered bunches in the vein mass at all of the openings. The sample selected for examination represents the heaps at the mine. These appear to have been sorted for working. Analysis shows the sample to contain 11.2 per cent. of graphite.

The works are about 300 yards southeast of the mine, and on the west side of a small stream, which furnishes water-power. They contain the necessary stamps for crushing the ore, and other machinery for separating the plumbago from the rock; and with very little work they could be put in running order. The stream affords 130 feet head of running water, but the volume is insufficient for steady work; and the flume is out of repair. The present location is not as good as could be had on the Pequannock river, less than a mile from the mine; and the changes needed in the introduction of new methods of working could be as economically made at another location as in the present mill.

2. *Englemann Mine, Peapack.*—There have been no attempts to work this mine since it was first opened, which was about thirty years ago. The *vein*, as traced by the outcrop, is a long one, and is from 4 to 5 feet wide. It occurs in the gneissic rock. Two samples, collected several years ago, have been examined. They contain 13.04 and 14.95 per cent. respectively. The latter was above an average. This locality could be worked easily, as it has facilities for good drainage, and it is only four miles from railroad transportation, at Chester.

3. *George B. Sutton's Farm, Fairmount, Morris County.*—Graphite crops out in the fields and in the road about a quarter of a mile west of Fairmount, and in a belt which strikes northeast from the Califon road to the German Valley road. Lewis Barnes, of Philadelphia, holds a lease on the property for one year. Two trial pits, about 5 feet deep, have been dug on the side of the road. South of it, and a few rods away, there is a shaft 28 feet deep. The belt containing the graphite appears, from the outcrop, to be several yards wide. The lead occurs as one of the mineral components of the granitic rock. An average of the material got out of the shaft was tested, and found to contain 6.87 per cent. of graphite. The locality is 4 miles from the High Bridge railroad.

4. *Conover Farm, High Bridge, Hunterdon County.*—This locality is in Hunterdon county, and about half a mile south of High Bridge. It is on the farm of Charles Conover, and at the side of the road to Clinton. There are three openings, of which the deepest is not more than 20 feet down. The vein is narrow, and dips steeply towards the east-southeast, between walls of feldspathic gneiss.

5. *Peter A. Beavers' Farm, High Bridge, Hunterdon County.*—Graphite crops out in the road near the railroad, less than one-fourth mile west of the High Bridge station, and on the adjoining lands of Peter A. Beavers. The width of the outcrop in the road, as indicated by the color of the surface, is 20 feet. Two trial pits were dug last summer, in the field south of the road, by Theodore Hoffman, of Clinton, but they are not deep enough to test the ground fairly. A selected sample from the Beavers openings was found to contain 27.82 per cent. Another, taken as an average, had 10.09 per cent. The property has been leased by the Reading Graphite Company.

A quarter of a mile southerly from these openings, and on the eastern side of a small crook, the surface earth has in it many lumps of graphitic rock, which are as rich in black lead as the material dug by Mr. Hoffman. There is here an area of several square rods thus covered by graphite.

6. *Hackett Farm, Hunterdon County.*—The Hackett farm adjoins the Central railroad, between High Bridge and Annaudale. Black lead has been discovered on it, and the property has been leased by the Reading Graphite Company.

7. *Chester, Morris County.*—Black lead is seen in the Mendham

road, about a quarter of a mile east of the residence of the late Gen. Nathan A. Cooper, and two miles east of Chester. The outcrop is several yards wide. There has been no digging to test the extent of the vein or stratum carrying it. From a careful examination of the surface outcrop it was judged to contain from 6 to 8 per cent.

8. *Morristown and Mendham.*—Rock containing graphite has been observed on the road, at two points, between Morristown and Mendham. One of these is near the township line; the other is near Mendham. The latter outcrop appears to be connected with that on the Saunders farm, south of the turnpike. A specimen from near Mendham was tested, and found to have 7.89 per cent. of graphite. A sample from the Betts farm, near Morristown, contained 6 per cent.

9. *Henry Mitchell Farm, Washington Township, Morris County.*—A sample of graphite from this place was sent to the laboratory by Lyman Kice, of German Valley. It contained 6.01 per cent.

Two or three other localities have been heard of since the above notes were written, but there is no further information in hand about them.

There has been difficulty found in the attempt to separate the mineral from the rock in which it occurs. For the uses to which it is to be applied, it is necessary that it should be entirely free from other minerals. Some of the methods tried have failed to get out all the rock, and others have failed to separate the principal part of the black lead. A cheap and effective method of separating this mineral from the rock, would be a benefit to the public.

CLAYS.

1. *Clay from Otto Ernst.*—A white, sandy clay from the salt works property of Otto Ernst, near Morgan station and the Chesquake creek. The sample is reported by Mr. Ernst to represent a bed which is 16 feet thick, 1 foot under the surface, and 60 to 80 feet above high water level. A boring down to tide level did not penetrate any other clay beds.

Insoluble matter	60.78
Alumina	24.00
Oxide of Iron	1.80
Potash	1.99
Water (combined and hygroscopic)	10.30
Total determined	98.87

This clay has been used by W. C. Coolidge & Co., at Poughkeepsie, in the manufacture of Portland cement, for the bridge piers at that place.

2. *Clay from Hulziser Farm, near Stewartsville, Warren County.*—Clay was discovered on lands of Hulziser, southeast of Stewartsville, and three-fourths of a mile northwest of Kennedy's mills, in digging for hematite. The pits are in a flat, 100 to 200 yards northwest of Hulziser's house, and on both sides of the public road. The deposit, as it has been opened, runs in a northwest and southeast direction The deepest pit goes down 35 feet. The top earth is a drift, including gravel and small cobblestones, and a little hematite. The clay-bed is 20 feet thick. Under it there is a yellowish and more sandy clay to the bottom of the pit. A drift, several yards in length, has been cut in the clay-bed. The deposit crops out in the field west of the road. It was found there also, in the pits dug for ore. A selected sample of clay from the main pit and shaft has been analyzed, and found to contain:

Alumina	27.31	per cent.
Silicic acid	56.95	"
Water (total)	6.40	"
Sesquioxide of iron	1.29	"
Lime	traces.	
Magnesia	1.66	"
Potash	5.56	"
Total	99.17	

It is remarkably white, and the sand in it is feldspar in fine particles. It does not burn white, on account of the iron oxide which it contains.

GREENSAND MARLS.

1. *Marls from the Farm of John E. Hunt, Manalapan, Monmouth County. Sent by D. Augustus Vanderveer.*—Three samples were received, of which two were examined for the lime and phosphoric acid. The vertical section at the pits, whence these came, has the following layers:

(1) Top dirt	2	feet.
(2) Cemented iron sand	1½	"
(3) Gray marl	2	"
(4) Black marl	4	"
(5) Sand marl	4	"

The grey marl had 0.25 per cent. of lime and 1.83 per cent. of phosphoric acid. The black marl gave 4.9 per cent. of lime and 3.2 per cent. of phosphoric acid. The phosphate of lime is very light in the grey marl, while in the black marl it is unusually large. The pits are in the Lower Marl Bed. The results of these examinations show the great variation in the different layers of the marl and the importance of selecting the rich marls, especially for use at any long distance from the pits.

2. *Marl from the Pits of the Kirkwood Marl Co., at Kirkwood, Camden County.*—This specimen was sent to the laboratory in May, 1879, by P. V. Voorhees, Esq., of Camden.

ANALYSIS.

Phosphoric acid	0.70
Silicic acid and sand	50.30
Potash	6.30
Lime	1.15
Magnesia	3.60
Alumina	6.88
Oxide of iron	19.92
Water	10.50
Total	99.35

3. *Marls from Prospertown, Monmouth County.*—Two specimens were received from Hon. E. P. Emson, of Ocean county. They were examed for phosphoric acid only. The marl from Lyall's old mill, known as Old Pond Marl, contained 0.32 per cent. That from near mill had 0.13 per cent. These marls contain much less phosphoric acid than marls from a lower level. They are useful as additions to the soil, when applied in large quantity.

Peat.—Two samples of peat from the farm of Dr. Theo. T. Price, near Tuckerton, have been examined. One is from a fresh-water swamp; the other was obtained from an old pine swamp, at the border of the tide marsh.

	1.	2.
Ash	9.89	23.06
Insoluble in acid	7.10	18.80
Lime	0.27	0.25
Phosphoric acid	0.032	0.077
Nitrogen	0.764	0.829

1. Fresh-water swamp peat.
2. Tide-marsh border peat.

Of the muck found on the tide-marsh border, a large quantity has been advantageously used. It needs to be composted with barn-yard manure, or else with lime.

METEOROLOGY AND CLIMATE.

In 1868 there was published in the "Geology of New Jersey" an appendix of meteorological tables, which gave the temperature and rain-fall at a number of places in the State. Last spring the preparation of a report on the climate of New Jersey was begun, and a large amount of material was collected for it. The Smithsonian Institution and the United States Signal Service Bureau furnished copies of the records of temperature and rain-fall made at their stations in the State and at several places in New York, Pennsylvania, Delaware and Maryland, which are so near our borders as to be serviceable in making a correct exhibit for the whole State. Weather records, kept by private individuals and companies, have also been received. The following list gives the location and period of observation at these several places. These latter terminate with the year 1878, excepting a very few, where it is known that they have been continued throughout 1879.

STATIONS.	LOCATION.	PERIOD OF OBSERVATIONS.
Goshen	*Orange county, N. Y.*	11 years.
Newton	Sussex county.	2 years (incomplete).
Easton	*Pennsylvania.*	5 years.
Lake Hopatcong	Morris county.	(Rainfall, 24 years.)
Dover	Morris county.	2 years, 10 months.
New York city	*New York.*	30 years.
Fort Columbus	*New York.*	48 years, 8 months.
Jersey City	Hudson county.	7 years (incomplete).
Paterson	Passaic county.	9 years (incomplete).
Bloomfield	Essex county.	6 years.
East Orange	Essex county.	2 years (incomplete).
Orange	Essex county.	2 years, 6 months.
South Orange	Essex county.	9 years (incomplete).
Newark	Essex county.	36 years, 7 months.
Passaic Valley	Union county.	2 months.
Linden	Union county.	2 years, 2 months.
New Germantown	Hunterdon county.	9 years (incomplete).
Pleasant Run	Hunterdon county.	5 months.
Readington	Hunterdon county.	7 years (incomplete).
Lesser Cross Roads	Somerset county.	2 years (incomplete).
White House	Hunterdon county.	2 months.
Sergeantville	Hunterdon county.	1 year, 3 months.

STATIONS.	LOCATION.	PERIOD OF OBSERVATIONS.
Princeton	Mercer county.	....
Pennington	Mercer county.	1 year (incomplete).
Roycefield	Somerset county.	2 years (incomplete).
New Brunswick	Middlesex county.	12 years (incomplete).
Lambertville	Hunterdon county.	19 years.
Trenton	Mercer county.	19 years (incomplete).
Morrisville	*Pennsylvania.*	67 years, 10 months.
Sandy Hook	Monmouth county.	5 years, 2 months.
Riceville	Monmouth county.	8 months.
Middletown	Monmouth county.	3 years, 2 months.
Long Branch	Monmouth county.	3 years (incomplete).
Ocean Grove	Monmouth county.	3 years (incomplete).
Squan Beach	Monmouth county.	3 years (incomplete).
Barnegat	Ocean county.	5 years, 3 months.
Atlantic City	Atlantic county.	5 years, 3 months.
Somers' Point	Atlantic county.	1 month.
Peck's Beach	Cape May county.	3 years (incomplete).
Freehold	Monmouth county.	12 years (incomplete).
Hightstown	Mercer county.	8 months.
Mount Holly	Burlington county.	11 years (incomplete).
Moorestown	Burlington county.	15 years (incomplete).
Haddonfield	Camden county.	7 years (incomplete).
Atco	Camden county.	9 years (incomplete).
Elwood	Atlantic county.	9 months.
Newfield	Gloucester county.	4 years (incomplete).
Vineland	Cumberland county.	13 years (incomplete).
Florence	Burlington county.	1 month.
Burlington	Burlington county.	10 years (incomplete).
Progress	Burlington county.	3 years (incomplete).
Camden	Camden county.	1 year (incomplete).
Philadelphia	*Pennsylvania.*	48 years.
Woodstown	Salem county.	3 months.
Salem	Salem county.	2 years (incomplete).
Fort Delaware	*Delaware.*	18 years, 10 months.
Allowaystown	Salem county.	3 years (incomplete).
Dover	*Delaware.*	9 years (incomplete).
Milford	*Delaware.*	9 years (incomplete).
Greenwich	Cumberland county.	10 years (incomplete).
Seaville	Cape May county.	4 years (incomplete).
Rio Grande	Cape May county.	7 years (incomplete).
Cape May	Cape May county.	5 years, 3 months.

After classifying these stations in groups, or climatic districts, it was found that the valley of the upper Delaware, the Kittatinny valley, the Highlands, and the south-central part of the State, were not well represented, or by incomplete records only. To fill out these

gaps, and to ascertain the climatic features of all parts of the State, six new stations have been started by the Geological Survey, and observations are to be taken at these places during 1880. Thermometers and rain gauges have been put in charge of the following persons, who have consented to keep records of temperature and rain-fall:

Chas. F. Van Inwegen, Port Jervis, N. Y.; A. C. Noble, Deckertown, Sussex county; Wm. Allen Smith, Weldon Mine, Morris county; L. H. Hunt, Schooley's Mountain, Morris county; Joseph C. Kent, Phillipsburg, Warren county; Eayre Oliphant, New Lisbon, Burlington county. The careful comparison of the records at these selected points for the same year (1880) with those of stations of long periods, will show the characteristic differences, and enable us at the end of another year, and in the next annual report, to publish the climatology of the State.

11. STATISTICS.

IRON ORE.

The product of the iron mines of the State for the year 1879, as derived from the ore tonnage of the Morris canal, the New Jersey Midland railway, the Delaware, Lackawanna, and Western railroad, the Central railroad, the Easton and Amboy railroad, and the Ogden Mine railroad, and the returns from Oxford furnace and from Franklin, was 488,028 tons. The returns for 1878 amounted to 409,674 tons. The increase for the last year is 78,354 tons, or 19 per cent. A small part of this aggregate tonnage of the transportation companies was mined in 1878, as the brisk demand for ore at the close of 1879 occasioned the removal of stocks which had accumulated at a few of the mines. The statistics of individual mines as they have been received will be found under their respective heads on pages 41–63.

ANTHRACITE BLAST FURNACES IN NEW JERSEY.

NAME OF WORKS AND LOCATION.	PROPRIETORS.	No. OF FURNACES.	REMARKS.
Franklin, Franklin, Sussex Co.	Franklin Iron Co.	1	Put in blast in July, 1879.
Musconetcong Iron Works, Stanhope, Sussex Co.	A. Pardee & Co.	2	In blast; large furnace was lighted Nov., 1879.
Warren, Hackettstown, Warren Co.	Joseph Wharton	1	Preparing to go in blast.
Pequest, Oxford, Warren Co.	Cooper, Hewitt & Co.	1	In blast (lighted February, 1880.)
Oxford Furnace, Warren Co.	Oxford Iron Co.	2	One in blast and one preparing to go in blast.
Phillipsburg, Warren Co.	Andover Iron Co.	3	In blast.
Chester, Morris Co.	Jersey Spiegel and Iron Co. W. J. Taylor & Co, lessees.	1	In blast.
Port Oram, Morris Co	Port Oram Furnace Co.	1	Lighted January, 1880.
Boonton Iron Works, Boonton, Morris Co.	Executors of J. Cooper Lord.	2	One at work. One preparing to go in blast.
Ringwood Iron Works, Ringwood, Passaic Co.	Cooper, Hewitt & Co.	2	One in blast. One about to be rebuilt.
Secaucus Iron Works, Secaucus, Hudson Co.	Secaucus Iron Co., A. Pardee, President.	1	In blast.
		17	

Of the 17 stacks, 13 are now in blast and 3 more will be lighted within a month, and all of them will probably be in operation during the year 1880. The yearly capacity of the 17 furnaces is estimated to be, at least, 200,000 tons of iron.*

In addition to the above-mentioned furnaces, there is a charcoal furnace at Splitrock, at work, in which wrought iron is made, using the Wilson patent. And near Drakesville, Morris county, is Möller's furnace—not in operation.

The following list of furnaces and forges which have been in operation at some former time, is of much historic interest, and may be of some practical information. Further information in regard to many of them is desirable:

* According to a table in a recent number of the *Iron Age*, showing the "Condition of the Blast Furnaces of the United States, January 1st, 1880," 11 furnaces in the State are in blast, and their capacity per week is 3210 tons, equivalent to 166,920 tons a year. There are 4 spiegel furnaces, 3 of which are in blast, making 132 tons a week.

CHARCOAL BLAST FURNACES.

NAME.	LOCATION.	REMARKS.
Wawayanda	Vernon twp., Sussex Co	Built in 1845; out of blast since 1856.
Hamburgh	Hamburgh, " "	
Franklin	Franklin, " "	Built in 1770; last repaired in 1854.
Ogden's	Odgensburg, " "	In existence before 1759.
Andover	Andover, " "	Built in 1763.
Clinton	West Milford twp., Passaic Co	Stopped in 1849; in ruins.
Long Pond	Ringwood Works, " "	Built, 1764–7; rebuilt as an anthracite furnace.
Ringwood	Ringwood, " "	Built, 1764–7; a ruin.
Freedom	Wynokie Valley, " "	1838; out of blast 1855, and down.
Pompton	Pompton, " "	1837.
Ryerson's	Bloomingdale, " "	In ruins.
Charlottenburg	Charlottenburg, " "	1767; was abandoned 1772.
Mount Hope	Mount Hope, Morris Co	1772.
Splitrock	Splitrock, " "	
Hibernia	Hibernia, " "	Built before 1764.
	Old Boonton, " "	
	Changewater, Warren Co.	
Oxford	Oxford, " "	Built in 1742–3; rebuilt, and in blast.
Union	Near High Bridge, Hunterdon Co.,	In existence in 1759; abandoned in 1778, and a ruin.
Amesbury	" " " " "	1755(?) in ruins.
Morris Iron W'ks	Tinton Falls, Monmouth Co	At work in 1682.
Howell	Manasquan river, " "	
Bergen Iron W'ks	Bricksburg, Ocean Co.	
Dover	Manchester, " "	
Phœnix	1 mile east of Manchester, Ocean Co.	In ruins, (Gordon's map.)
Hanover	Hanover, Burlington Co	Idle since 1854.
Mount Holly	Mount Holly, " "	Mentioned by Acrelius in 1759.
Mary Ann	Pemberton twp., " "	
Union Works	Woodland twp., " "	
Speedwell	" " " "	
Hampton	Shamong twp., " "	
Atsion	" " " "	
Batsto	Washington twp., Burlington Co	Built in 1766; ran until 1855.
Martha	" " " "	
Taunton	Medford twp., " "	
Gloucester	Mullica twp., Atlantic Co.	
Weymouth	Hamilton twp., " "	Idle since 1854.
Etna	Weymouth twp., " "	
Cumberland	Manumuskin, Cumberland Co	Out of blast since 1844.
Millville	Millville, " "	Built 1815; out of blast since 1855.
Bridgeton	Bridgeton, " "	
Tuckahoe	Tuckahoe, Cape May Co.	

All of these were charcoal furnaces. None of them have been in operation since 1856, and all in the southern part of the State are abandoned. Atsion was at work last. Oxford, Franklin, and Ringwood have been rebuilt as anthracite furnaces.

FORGES.

NAME.	LOCATION.	REMARKS.
	Canistear, Vernon township, Sussex Co.	1796.
	Franklin, Hardiston " "	
	Windham, " " "	Built about 1790.
	Sparta, "	Two forges, 1821–3.
Morris Anchor w'ks	Norman's Pond, Sparta twp., "	" "
Hopewell...............	Hopewell, " " "	1780.
Columbia...............	Byram township, "	1800.
Roseville...............	" " "	1828.
Lockwood...............	" " "	1857.
Andover...............	" " "	1804.
Stanhope...............	" " "	
Clinton...............	West Milford township, Passaic Co.	
Stockholm...............	" " " "	At and near Stockholm there are 4 forges.
Charlotteburg.........	Charlotteburg, West Milford township, Passaic county........................	Built in 1840.
	Pequannock Valley, West Milford twp., Passaic county.	There were 2 forges between Charlotteburg and Smith's, in the time of the London Co.
Smith's...............	Smith Mills, West Milford township, Passaic county.	
Vreeland's............	1 mile w. of Bloomingdale, Passaic Co.	
Ryerson's.............	Bloomingdale, Passaic county............	Built about 1800.
Long Pond............	Ringwood Works, Passaic county......	Built by Hasenclever, 1764-1767.
	Ringwood Works, " "	Three forges were built by Hasenclever in 1764.
	Boardville, " "	
	Wynokie, " "	
	Schraalenberg, Bergen county...........	According to Gordon's map.
	Russia, Jefferson township, Morris Co.	1775.
	Weldon " " " "	
	Hurdtown " " " "	
Swedeland.............	Milton " " " "	1801.
	Petersburg, " " " "	Two forges according to Gordon's map, at Petersburg.
	Woodstock " " " "	1790.
	Upper Longwood, Jefferson township, Morris county.	

NAME.	LOCATION.	REMARKS.
	Lower Longwood, Jefferson township, Morris county	There have been 2 forges atLowerLongwood and
	Berkshire Valley, Jefferson township, Morris county.	in the Berkshire and Longwood valleys the map of Gordon has 6 in all.
Valley	Near Baker's Mills, Roxbury township, Morris county	1780.
Washington	On Rockaway river, Rockaway township, Morris county	1850.
Mount Pleasant	Mount Pleasant, Rockaway township, Morris county	In ruins.
Ætna	Near Middle Forge, Rockaway township, Morris county	Built about Revolution.
Middle	Middle Forge, Rockaway township, Morris county	1810.
Denmark	Denmark, Rockaway township, Morris county	1800.
Timber Brook	Southwest of Charlotteburg, Rockaway township, Morris county.	
Durham	Southwest of Charlotteburg, Rockaway township, Morris county	1811–1856.
Earle's	Stony Brook, Pequannock township, Morris county	1822–1856.
Decker's	Rockaway valley, Pequannock township, Morris county	1846.
Dixon's	Rockaway valley, Rockaway township, Morris county	1827.
Splitrock	Splitrock, Rockaway twp., Morris Co.	About 1837.
Stickel's	Meriden, " " " "	1790.
Righter's	Meriden, " " " "	1820.
Beach Glen	Beach Glen, " " " "	Built in 1760.
Hibernia	Hibernia, " " " "	Gordon's map has two forges here.
Muir's	On White Meadow Brook, Rockaway township, Morris county.	
	Rockaway, Rockaway twp., Morris Co.	There are 2 forges here, 1790–1805; and Gordon's map has 2 additional on Horse Pond branch.
	Powerville, Morris county	Built 1853.
	Boonton, " "	Gordon's map has two forges here.
Righter's	Old Boonton, Hanover twp., Morris Co.	Built 1853.
Troy	Troy, " " " "	1745–1859.
Whippany	Whippany " " " "	Built in 1710.
	Speedwell, Morris township, Morris Co.	Gordon's map has two forges, w. & n. w. of Speedwell's works.
	Morristown, " " " "	According to Gordon's map.
	Shongum, Randolph " " "	On Den Brook, below Shongum, Gordon has 2 forges.

NAME.	LOCATION.	REMARKS.
	N. branch of Raritan, Mendham township, Morris county	Two forges, according to Gordon's map.
Budd's	Hacklebarney, Chester twp., Morris Co.	1850.
Budd's	Black River, " " " "	
Welsh's	1 mile below Bartleyville, Mount Olive township, Morris county.	
Bartleyville	Bartleyville, Mount Olive township, Morris county	1790.
Mount Olive, or Stephen's	1 mile above Bartleyville, Mount Olive ship, Morris county	
Shippenport	Shippenport, Morris county	1843.
Solitude	Near High Bridge, Hunterdon county.	
	Spottswood, Middlesex county.	
	Imlaystown, Upper Freehold, Monmouth county	Built in 1716.
Jackson's	Near Squankum, Monmouth county.	
Three Partners	Near Bricksburg, Ocean county	According to Gordon.
Butcher's Works	Near Burrsville, "	
	Dover, Ocean county	In operation 1866-7.
	Ferrago, Ocean county	Stopped in 1851.
	Westecunk (West Creek), Ocean Co.	
	Hampton, Shamong township, Burlington county	
	Monroe, Weymouth twp., Atlantic Co.	
	Manumuskin, Cumberland county.	

There was probably a forge at Tinton Falls as early as 1682, according to the statements of the East Jersey proprietaries, belonging to Lewis Morris' iron works.

The forges on the Pequannock, below Charlotteburg, those about Ringwood, that at Russia, Ætna forge, Hibernia, Troy, Whippany, Solitude, and Imlaystown, also antedate the Revolution. According to a census in 1784, the State had 8 blast furnaces and 79 forges. Gordon, in his statistical table published in 1834, has 12 blast furnaces and 108 *forge fires*. There were 14 forges in south Jersey at that date. The forge at Dover, in Ocean county, was at work in 1866–7. In the northern part of the State, Shippenport, Russia, Stockholm, Ryersons, at Bloomingdale, Powerville, Splitrock, and Middle forges, have been at work for short periods, at intervals, up to the present time.

ZINC ORE.

The zinc mines in the State have been worked steadily throughout the year, and they have produced 21,937 tons of ore.*

At Stirling Hill, near Ogdensburg, Sussex county, there are three mines, worked by three distinct companies: the Manganese Iron Company, at the southwest; the mine of the Passaic Zinc Company has been in operation throughout the year; the mine of the New Jersey Zinc Company is still idle.

At Franklin, three parties are at work on Mine Hill. The Franklin Iron Company is mining in the opening known as the "Buckwheat." To the northeast of the Buckwheat opening, a shaft has been sunk over 100 feet, in search of the *Buckwheat vein*, but thus far without success. The old Greer opening is now worked by Chas. W. Trotter, on a lease. But a small quantity of ore is mined.

The New Jersey Zinc Company has the northern end of the vein, and is working on both sides of the Hamburg road. The vein at their northernmost drifts is large.

CLAYS AND BRICK.

The clay deposits of the State were described at length in a special report published two years ago. In the Annual Report for 1878 there was a supplementary notice of the clays of the southern part of the State. The demand for these reports has been steady and large, indicating the interest manifested in the development of that part of our mineral resources. The general improvement in business began to show itself in the autumn, in larger and in an increasing number of orders for clays and brick. The needed repairs at so many of the iron works created a brisk demand for fire-bricks and for the refractory materials used in their manufacture. The fire-brick works, for a few months, have had as much as they could do to fill orders, and the clay miners have found a good market and fair prices. The superior quality of our fire-clays, and their adaptation to so varied uses, are gradually being found out by a continually widening circle of manufacturers, and they are more and more appreciated by them.

The statistics of the clay district of Middlesex county, according to the three principal groups of pits, are as follows:

* This estimate includes 15,937 tons of ore carried on the Morris canal, and 6000 tons of ore mined, but not shipped, by the Passaic Zinc Company, at Stirling Hill.

1. Woodbridge.* Fire-clay, fire-sand, *kaolin* and fire-brick shipped...	115,060	tons.
2. Clay banks north shore of Raritan river.† Fire-clay and fire-sand and *kaolin*........	90,000	"
3. Clay banks on south side of Raritan river.‡ Fire-clay and fire-sand and *kaolin*........	60,000	"
Total refractory materials........	265,000	"

This aggregate is not quite equal to the tonnage of clay mined, as, in the estimate for Woodbridge, the fire-brick shipped do not weigh as much as the clay and sand which are used in them. It is equal to that of 1873, which was a prosperous year.

The product of the mines and pits of stoneware clay in Middlesex county is estimated for the year to be 10,000 tons,§ or about half of that of the best previous annual output.

The clay banks on the Delaware side of the State, excepting that of John D. Hylton, on Pensauken creek, in Camden county, are not extensive, and their aggregate product is small. The shipments from Hylton's banks‖ during the year 1879 consisted of—

Fire-clay........	9,777	gross tons.
Fire-sand........	3,220	"
Kaolin........	4,350	"
Spar........	1,000	"
Sharp sand........	5,000	"
Moulding-sand for fire-brick........	1,500	"
Total of refractory materials........	31,847	"

In the business of making red brick, the revival came so late in the season that the brickmakers were not prepared to take advantage of the market. Along the Raritan and South rivers, the principal seat of this business, many of the yards were not worked to their full capacity until September. Mr. Higbie estimates the product of the yards on the Raritan and the South rivers, during the year 1879, at 87,000,000. According to the present outlook, and at the present capacity, the same authority puts the estimates for next year at 110,000,000.

The importance of the clay industry on the eastern side of the State is shown in the valuation of the product. At an average of

* Reported by Wm. H. Berry, of Woodbridge.

† Reported by Chas. A. Campbell, of Woodbridge.

‡ Reported by M. S. Higbie (of Sayre & Fisher), Newark, and George Such, of South Amboy.

§ Reported by Otto Ernst, of South Amboy.

‖ Reported by John D. Hylton, of Palmyra.

$2 per ton, the amount of sales would be at least half a million of dollars. The greater part of this raw material is manufactured into fire-brick, retorts, drain-pipe, terra-cotta, and wares, at works in the neighborhood of the pits. A considerable amount is shipped to the furnaces along the Lehigh, in Pennsylvania, and elsewhere. The location of this clay district—with such a length of water-front, with its lines of railroad in direct connection with the coal and iron regions, and its nearness to the large markets of the Atlantic seaboard—gives it advantages which must hasten its development.

The Raritan river, along which the clay beds are so largely developed, opens most convenient and cheap transportation to all parts of our coast. It is already the fourth river in the United States in tonnage, and the general government has begun an improvement in deepening the channel so as to provide still greater facilities for the immense business which is to be done upon it. The work has been in progress less than two years, and already manufacturers and shippers have felt the benefit of the great improvement which is being prosecuted in deepening the channel, and they are now enabled to load direct on vessels of deep draught of water, and thus secure cheap transportation to all points on the coast, which, added to the inexhaustible supply of raw material and improved facilities in working the same, enables them to compete with local works at distant points, and they are no longer dependent upon the demand in New York and vicinity. Should the improvement in regard to the Raritan river, as contemplated by the general government, be completed, the number of red brick made on this river will soon exceed 200,000,000 per annum, with a corresponding increase in all other branches of the clay business.

The adaptation of these clays for fire-brick and stone-ware are so well known that it is unnecessary to refer to these uses.

The employment of the dense clay of the Raritan fire-clay stratum for glass-pots has been suggested, and some experiments with it have been tried. This clay differs but little in composition from the best Woodbridge and South Amboy fire-clays; but it burns very solid and free from checks, resembling in this respect the best of the foreign clays which are imported for making crucibles and glass-pots and strong fire-brick. There is an abundance of this clay of the best quality, and it can be afforded at half the cost of that imported. It only needs

proper care on the part of owners and consumers to bring it into general use. It has been dug by William B. Dixon at Woodbridge, and by B. Ellison and Augustine Campbell on their farms near Bonhamtown. These localities are shown on the map accompanying the report on clays. The following extract from one of the reports made to the U. S. Potters' Association, at their recent annual meeting, in regard to the sale of reliable and uniform grades of clay, states the case for this as well as for all our varieties of clay in the proper form:

"Clays must be graded and sold according to grade, and each miner will be compelled, sooner or later, to establish their brand and make their clays entirely reliable, so they can be purchased by their brands, as has been done for many years in Europe.

"But before a brand of clay can be made reliable, the clay must be made uniform, which cannot be done by working clay beds in small sections. To this point your committee would call especial attention.

"All beds of clay vary more or less, even in the best strata the variation is perceptible every few feet; consequently a mine worked in small sections, or pockets, as our American clays are, and always have been worked, and sent to market as fast as they are washed, do not properly represent the clays of that mine, but, on the contrary, represent each time one small spot in the mine, the result being that every invoice of clay from our American mines is different, consequently our mixtures made from these clays are always changing and unreliable, causing losses that we have been entirely unable to account for."

The finer grades of white clay which are dug in the vicinity of Woodbridge and Amboy are extensively used in the manufacture of cream-colored and white-granite wares. Their superior plasticity is useful in mixing with the kaolin-clays of Delaware, which are not plastic. On account of the oxide of iron they do not burn white, as the kaolin-clays. A practical method of removing this constituent would be a valuable discovery, as it would permit of their use in place of the more costly and less plastic clays which are employed. For saggars there is a large amount of New Jersey clay used.

The employment of our clays for making terra-cotta has been enlarged greatly by the starting of the manufacture by Mr. A. Hall, at Perth Amboy. The works are known as the "Perth Amboy Terra-cotta Works." They are doing a large business, and furnish orna-

mental material of a high character. Terra-cotta is made at the Pea-Shore Fire-brick and Terra-cotta Works, near Camden.

At South Amboy a pottery has been recently built by the Juliano Ware Co., which will use clays from the neighborhood in the manufacture of their wares.

At Eagleswood a buff clay, suitable for modeling, has lately been opened on the Eagleswood estate; and it is used by the owner, Edward A. Spring, in his art pottery.

Statistics of Potteries making White Ware at Trenton, Elizabeth, and Jersey City.—From J. H. Brewer, Etruria Pottery Co., Trenton, and President of the United States Potters' Association.

Number of kilns.......101
Average capacity (each)....... $30,000
Amount produced, if fully employed.......$3,030 000
Amount actually produced, about.......$2,500,000
Amount produced in United States.......$4,000,000
Amount imported, about.......$4,000,000
Production of New Jersey (clays, flint and spar,) 50,000 tons.
Coal used, 50,000 tons.
Wages paid, yearly, $1,250,000.
Hands employed, 3,000.

GLASS WORKS IN NEW JERSEY.

LOCATION.	PROPRIETORS.	NO. OF FACTORIES.	REMARKS.
Jersey City		2	Not in operation.
Medford			"
Jackson			"
Waterford			"
Winslow	A. K. Hay & Co.	3	In operation.
Tansboro	Bodine & Sons	1	"
New Brooklyn			Not in operation.
Williamstown	Bodine & Thomas	2	In operation.
Glassboro	Whitney Bros.	4	"
"	Warrick & Stanger	2	"
Clayton	Moore Bros.	4	"
Malaga	Malaga Glass Manufacturing Co.	2	"
Salem	John V. Craven	3	"
Quinton	Hires & Plummer	2	"
Bridgeton	Cohansey Glass Co.	5	"
Millville	Whitall, Tatum & Co.	10	"
Estellville			Not in operation.
Crowleytown			"
Green Bank			"
Total in operation		38	

The following statement from R. M. Atwater, of Whitall, Tatum & Co., Millville, gives the condition of this industry in our State at the present time:

"These factories vary in size. I should say that on an average they melted 2 to 2½ tons of sand each day, and turned out a product of full 3 tons each, of packed glass daily. The glass is in all cases a 'lime-glass,' composed chiefly of sand fluxed with soda and lime. The sand is generally mined in the State. In some of the factories making finer qualities of glass, the sand from quartz is used, which is obtained from the Alleghany Mountains. The lime is generally obtained from oyster shells, or from the limestone deposits of New Jersey and Pennsylvania. The soda ash is imported. Some use is made of salt-cake (sulphate of soda.) Each hollow-ware factory employs about 100 hands. The work is piece-work, and the glass-blowers can earn from $2.50 to $4 per day. Their work consists of the general class of bottles. There are no factories running on table glass-ware, lamps or pressed ware, to any extent in the State. I extract the following note from the *Crockery Journal:*

"'Of the 106 window-glass factories in the United States, 34 are in New Jersey. Each factory employs about 50 to 75 persons.'"

In addition to the supply of the glass works in the State, the glass-sand pits along the Maurice river sell from 10,000 to 15,000 tons annually to works in adjoining States. The localities where glass-sand is dug were described in last year's report.

GREENSAND MARLS.

The importance of this natural fertilizer to the farming interests of the southern part of the State is so great that some account of the condition of the marl trade is necessary and desirable. In the last Annual Report the belts of oak-lands southeast of the marl district were described, and represented on the map accompanying that Report. The clearing and settling of these lands must create a demand for fertilizers. And along the whole length of the southern half of the State, from the Atlantic to the Delaware river, there is, bordering these oak-lands, the marl-belt. The supply of good marl is practically inexhaustible. The railroad communication between the marl district and the country to the southeast of it is shown on the map

with this Report. The state of the marl trade is much better than it was last year, and the outlook for the ensuing year is very promising. The prices have been reduced. This reduction in cost, and better prices for farm produce, enable the farmers to buy largely again. One of the agents writes: "We have reduced our prices to the lowest possible point, and hope for larger sales this season." Another says: "Our company * * * made a deduction of price of marl from 10 to 30 cents per ton, according to the distance carried." There seems to be an earnest endeavor, on the part of the companies selling marl, to increase sales and to extend their business by the inducements of low rates. The co-operation of the railroad lines with the marl companies, in the reduction of rates, is very desirable. Hitherto they have in many places been exclusive, as the farmers could not afford to buy at the schedule prices. The subject is again referred to, as it is of importance to both carriers and buyers. In order to get the statistics of the marl sold and carried on the railroads, letters were sent to officials of the companies. These are here printed. It is hoped that the publication of these statistics will tend to increase the business of the companies, and call the attention of our farmers and those engaged in the improvement of land to the great extent of the marl belt, its richness and fertility—due to the generous use of this natural fertilizer—and the capabilities of southeastern New Jersey under like treatment.

FREEHOLD AND NEW YORK RAILWAY.

J. E. Ralph, Secretary, Treasurer, and Superintendent, writes: The F. and N. Y. railway, for the 12 months ending December 31st, 1879, hauled 324 car-loads, of 250 bushels each, = 81,000 bushels.............. 4,050 tons.

SQUANKUM MARL COMPANY.

W. E. Barrett, Superintendent, writes: Our sales, ending with the 1st of March, 1879, were about 150,000 bushels; equivalent to................ 7,500 "

SQUANKUM AND FREEHOLD MARL COMPANY.

A. A. Yard, Superintendent, says: We have sold and delivered the past year ....10,000 "

CREAM RIDGE MARL COMPANY.

Gen. G. Mott, Treasurer, writes that the company has sent out.............. 4,710 "

PEMBERTON MARL COMPANY.

J. C. Gaskill, Superintendent, writes: Our sales for the year 1879 amount to..10,000 "

VINCENTOWN MARL COMPANY.

Henry J. Irick writes: We shipped during 1879	3,010 tons.

FOSTERTOWN MARL COMPANY.

R. S. Reeve, lessee, writes: Our sales of marl last year amounted to about	5,500 "

KIRKWOOD MARL AND FERTILIZER COMPANY.

George M. Rogers, Superintendent, writes: The Kirkwood Marl and Fertilizer Company was organized late in the season of 1879. The sales for the balance of the year amounted to	5,300 "

WEST JERSEY MARL AND TRANSPORTATION COMPANY.

I. C. Voorhies, Superintendent, says in letter, December 24th: We have delivered since January 1st, 1879, to present time	11,000 "

WOODSTOWN, SALEM COUNTY.

John W. Dickinson writes: The sales at the Dickinson marl beds this year will be about	3,000 ".
Total	64,070 "

The marl which is carried on the railroads is but a small part of the whole quantity dug in the State. The greater part of it is carted by teams directly from the pits to the farms whereon it is to be applied. Besides this, the aggregate of what is dug and used on the farms where it occurs is very large. To show how much is distributed by teams from a single locality, the following statistics of three farms at Marlborough, in Monmouth county, are here given. These pits are all within a half a mile of one another. The figures are exclusive of the amounts used at home. They are as follows:

O. C. Herbert's sales amounted to	9,814 tons.
Uriah Smock's " "	8,000 "
C. H. Conover's " "	1,750 "
Total	19,564 "

In the above figures, the amounts sold from these pits and sent away on cars is not included.

LIME.

No attempt has been made to collect the statistics of lime burned in the State. The blue, magnesian limestone is quarried extensively at several points along the Delaware, Lackawanna and Western, the Central, the Belvidere Delaware, and the Easton and Amboy railroads,

in Sussex, Warren, and Hunterdon counties, for kilns which supply lime to the country to the east and south of the limestone outcrops. A large amount of lime is delivered by teams in the neighborhood of kilns. Very nearly all of it is used for agricultural purposes.

The white, crystalline limestone has not been used to any such extent for lime, except in the vicinity of Hamburgh and McAfee valley, in Sussex county. A large amount of lime was formerly made on the Edsall farm, and sold in Paterson, Newark, and other towns in the State. Two years ago Sayre & Vanderhoof started the manufacture of lime near Hamburgh, and on the N. J. Midland railroad. They have two perpetual kilns. These are constructed with separate fire chambers, two on the sides of each kiln, and in such a manner that the flame only is in contact with the limestone. Wood is used as fuel. The stone is brought from the quarry on the Rude farm, which is two miles north of the kilns, in cars on a tramroad. It is very white and coarse crystalline, and, according to an analysis made for the "Geology of New Jersey," published in 1868, contains 99.5 per cent. of carbonate of lime. The lime is liked on account of its whiteness, and because it does not air-slake readily. It is shipped in lime cars to points on railroad lines in New Jersey. A large amount is sold in the southern part of the state. The fine lime is sold for agricultural uses. In 1879 the sales amounted to 30,000 barrels.

The use of this white limestone for making lime has been referred to in previous reports of the Survey, and its employment has been recommended. The success at Hamburgh confirms these statements, and suggests further trials and a more extended use. There is no reason why we should not supply New York as well as our own State.

The white limestone is quarried to a large extent in the valley of the Wallkill, at Stirling Hill, and near Franklin, for fluxing material in iron-making. Silsby & Martin sell the manganiferous limestone from their iron mine to Cooper, Hewitt & Co. It goes to the Ringwood furnace.

The Franklin Iron Co. gets its supply of limestone from the ledges at the side of the N. J. Midland railroad, and a few rods from the furnace. It is coarse, crystalline and white. The same range of limestone is quarried a short distance south of Franklin, for the supply of other furnaces.

12. PUBLICATIONS OF THE SURVEY.

The Annual Reports of the progress of the State Geological Survey are printed among the documents of the State, and they are very generally distributed by the members of the Legislature among their constituents. A liberal number of copies is also placed at the disposal of the members of the Board of Managers and the Geologist. The demand for them, however, is large, and those of 1876, 1874, 1873 and 1872 are all distributed, so that for those years no copies can be furnished.

The "Geology of New Jersey," an octavo volume, with a portfolio of maps, published in 1868, can still be supplied, though the number of copies left is not large.

The "Report on the Fire and Potters' Clays of New Jersey," with a map of the clay district, which was completed two years ago, has been widely distributed both at home and in foreign countries. The edition is probably sufficient for the present demand.

The large Geological Map of the State is mostly distributed, only a few copies being left.

The Geological Map of Northern New Jersey, which was printed in colors, and first distributed with the Annual Report of 1873, is out of print. A very large number of copies have been distributed.

The Centennial Map of New Jersey, on a scale of six miles to an inch, and showing geographical features only, was prepared by the survey, and has been distributed.

The proper method of making public the results of our Geological, Topographical and Economical Survey, is a question which has not been satisfactorily settled with us, and is equally unsettled in most other countries. At first the board resolved to sell the reports and maps at the cost of paper, printing and binding, and a considerable number of copies of the Geology of New Jersey and some of the maps were sold in that way, but there were always some copies at the disposal of

the members of the board and of other State officers, and the chance of getting from these without paying for them, led those who really wanted them to delay buying. From the way the printing is done the amount of free distribution has increased, and the sales have ceased. As the object of the Survey is to make known our natural products and resources, it may be said that we must do it by advertising—that is, by free publication and liberal distribution, just as in private business, and that the waste or misappropriation of a considerable part of the publication should not discredit the method so long as we continue to thrive in using it.

The Pennsylvania Reports are sold at the cost of printing and paper, but in fact most of them are given away.

The results of the Geological Survey of Great Britain are prepared and printed with great care and at heavy cost, and the price put on them is so high that few buy them.

The French Geological maps, too, are held at high prices, and few of them are sold.

The Board of Managers of the Geological Survey are constituted a board of publication of the results of the work, and they have authority to publish and distribute the reports as in their judgment is best for the interest of our citizens. It is specially desirable that the reports and maps should go into all public libraries, and into the hands of those whose pursuits render the information contained in these publications of value. It is probable that no better way will be devised for the distribution than to leave it in charge of the members of the board; and applications to them for such reports as may be desired, or to the State Geologist, with their approval, will be answered as far as possible.

The names and post-office addresses of the members of the board are on page 3.

13. EXPENSES.

The expenses of the Survey have been kept strictly within the appropriation. There is now standing to our credit on the Comptroller's books a small unexpended balance.

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14. ASSISTANTS.

The Assistants to the State Geologist, who have been engaged in the work of the Survey in the course of the year are:

PROF. JOHN C. SMOCK, Assistant Geologist. He has been steadily at geological work as required, in different parts of the State, and in addition has given particular attention to the collection of details of the geology of red sandstone regions, &c.

EDWIN H. BOGARDUS, Chemist of the Survey, has been occupied with laboratory work through the year. In addition to the analyses which appear in this report, much time has been given to making chemical tests, in answer to inquiries in regard to specimens, which are sent in from all parts of the State.

C. C. VERMEULE, B. S., Topographical Engineer and Surveyor, has been engaged during most of the year in the work connected with the topographical maps—measuring angles to determine geographical positions, surveying and leveling for the topography and drawing the map.

GEO. W. HOWELL, C. E., Surveyor and Civil Engineer, has been engaged, as far as other professional duties would allow, in making levels and surveys for the topographical map.

PROF. EDWARD A. BOWSER, has spent some time in computing the latitudes and longitudes of points in the triangulation of northeastern New Jersey.

My own time has been directed to the general progress of the work in its scientific and economical branches, and giving it such direction as may be most useful to the State in developing its natural resources.

It is proper also to mention the very great assistance rendered to the Survey by the numerous gentlemen who have contributed information and personal attention to further its objects. As the work gets to be better understood, information is more freely given to, as well as more generally sought from, the Survey. It would be an agreeable task to mention the names of those who have thus favored the work, but it would be difficult to tell where to end the list, and it is probably better to refer back to the body of the report, where the names are mentioned. Such assistance, however, is always gratefully received, and the thanks of the Board of Managers, and of the geologists, are hereby tendered to those gentlemen.

15. MUSEUM OF THE GEOLOGICAL SURVEY.

The museum of the Survey occupies the front rooms of the third story in the State House at Trenton. It is designed to be an exhibition of some of the results of the work of the Survey. There are in it collections of representative specimens from the mines of iron, zinc, and copper ores; from the fire-clay banks; from the glass-sand pits; from the greensand marl diggings; from the quarries of limestone, slate, flagging stone and building stone; and soils from the different agricultural districts of the State. Suites of rocks and fossils, characteristic of the geological formations, illustrate the geology of the State. There is a small collection of the more common minerals, and a few choice specimens of rarer species. The woods of the State are represented by about 100 varieties. In addition to these natural products,

there are fire-brick, pottery and glass wares, zinc oxide, spelter and irons from works in the State.

All the maps, both geological and geographical, of the State, so far as are known, are here.

Additions to the collections are made from time to time by the survey and through the kindly assistance of our citizens. Among these, recently placed on exhibition, are fossil fish in shale, from near Boonton, secured through the generous aid of H. Wilson Crane, of Boonton; and footprints in the red standstone from the quarry of John H. Vreeland, Hook Mountain. (See pages 27 and 28 of this report.)

There is need of much more material, both for the better illustration of our natural resources, and to make the museum more attractive to the many who visit it.* And attention is here asked to it as a safe repository and a proper place for the public exhibition of valuable and interesting specimens.

The museum is open daily, except Sundays.

New Jersey has pursued a liberal course with the Geological Survey thus far, and its prosperity during all the time it has been going on has been of the most marked character. The State has unequaled advantages in its location, its climate, and its natural resources. While it is of the 38 States in the Union only the 33d in size, it is the 17th in population, the 8th in the value of its real and personal property, the 20th in the value of its agricultural products, the 7th in the value of its manufactured products, and the 8th or 9th in the value of the products of its mines. In zinc ores it is the largest producer, and in the great staple, iron ore, it is the 3d or 4th.

Its increase in population and wealth for the last 30 years has been more rapid than that of any other of the older-settled States, and more rapid, too, than the average of the whole United States.

These results, so creditable to our State, are due, in addition to our natural advantages, to the liberal course with our schools; to ascertaining, developing, and publishing our natural resources; and to the strict, safe, and economical management of our finances.

The plan which we think best for the State is to continue the survey as at present until its triangulation by the United States

* No continuous record of the number of visitors has been kept, but it is estimated to be, on the average, 50 a day, or 15,000 in the course of the year.

Coast and Geodetic Survey shall be completed. Also, to have such topographical surveys and maps made of the mining districts of the State as cannot well be done by private enterprise; and to carry on such other topographical surveys as shall be necessary to make the State map on a scale of 2 miles to an inch, full and reliable for the public use. While this work is in progress, the detailed geology can be worked out and arranged so as to be put accurately on the maps, and published in three or four volumes, like that on the clays. There should also be prepared for publication a volume on the cretaceous fossils of New Jersey, with figures of the different species. This formation is more fully developed, and has been more studied, in this State than it has anywhere else in our country; and it is due to geological science that we should publish the typical and representative forms of the fossils which characterize it. To do this work will require the services of one specially devoted to the subject, and will involve an expense of perhaps $2000. The fossils in the older formations have been well studied and described in New York, Pennsylvania, and other States where these formations are more extensively developed than they are in this, and study and expense upon them need not be incurred by us.

All this work can be done fully in five years, and possibly in four or three years. When it is done the Survey can be closed, or reduced in expense to a bureau for recording progress in our material development and furnishing information in regard to our resources. A moderate annual expense for this purpose would undoubtedly be useful to the State for a long time to come.

CONTENTS.

INDEX.

A.

B.

F.

G.

H.

I.

Page.

Mines—

$\frac{7}{8}$